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The Estimation of Construction Expenses.

It is rather surprising that very little information has ever been printed concerning the methods followed by engineers and contractors in estimating the cost of large engineering undertakings. While there is an abundance of data of more or less complete character concerning the cost of carrying on certain classes of work, the published information concerning the total expense of conducting large operations is extremely meagre. In order, therefore, to furnish to students in engineering schools and to young engineers a fairly complete explanation of the processes that are followed in preparing estimates for large undertakings, The Engineering Record has obtained from Mr. J. Waldo Smith, chief engineer of the Board of Water Supply of New York City, some information concerning the manner in which certain parts of the cost of the main Ashokan dams and dikes were estimated by himself and his assistants. This work was selected for the purpose because the requirements of the specifications are of the most advanced nature, exceeding in their severity in a number of details the requirements for the majority of similar engineering works. Another reason for selecting this undertaking as an example, was the fact that during the construction of large dams in New Jersey, built by day labor under the direction of Mr. Smith, every item entering into their cost was known to him, so that his methods of estimating the Ashokan work are of special interest. It is impracticable within the limitations of such an article to go into the details followed in reaching all the various parts of the estimates, but it is believed that enough has been stated to explain the processes followed.

Another reason for printing this information is that there seems to be a general popular misunderstanding of what an estimate really is. It has been said a good many times that such an estimate is a "guess," but it is not understood that there is all the difference in the world between such a guess as the experienced engineer or contractor makes after a thorough study of the conditions and requirements for a proposed undertaking and the ordinary guess that a man makes about something with which he is unacquainted. In most branches of engineering it is necessary to assume that materials really have the properties they ought to have, that connections act as they are designed to act, that workmanship is of the character required in the specifications, and that in a complicated structure the distribution of stresses and strains follows certain simple assumptions. Every engineer knows that there are many uncertainties at every stage of the process of designing and building a large work, and consequently he makes allowances at each step for imperfection and uncertainty. He calls this allowance a factor of safety, or something of the sort. Owing to these uncertainties he makes some structures twice as strong as he figures they must be in order just to stand, while other kinds of structures he makes ten times stronger. In every part of the design it is necessary for him to apply his scientific information with a proper regard for the probable uncertainties of materials and workmanship; in other words, he must exercise his engineering judgment.

The case is just the same with estimates of the cost of construction on a large scale. No great undertakings like the Ashokan dams and dikes can possibly be estimated accurately. Nobody can foretell what labor expenses will be, what the weather and flood conditions will be, nor what changes in the political organization of the city and state may do to hamper or help the construction. It is possible to explore the conditions below the surface where the dams and dikes will be constructed, but it is impossible to tell exactly what problems may arise in putting in the foundations for such a great work as the main dam. Experience has shown that it is often desirable to go far deeper down into bed rock than preliminary borings indicate will be necessary, and the cost of this work may be very great. A long list of similar conditions might be mentioned, all of which have more or less uncertainty connected with them. The best that can be done is to estimate the cost of the different kinds of work in the light of experience with similar work in other situations, making such allowances for the difference in conditions as seem necessary. There is nothing exact about such a process, because the conditions render exactness impossible. It is essentially a process of "guessing," although those men who have had most experience are able to guess most closely. It is believed, therefore, that the explanation of the methods of estimating the cost of the Ashokan work given elsewhere in this issue will prove of interest to many people who have been somewhat startled by a too literal interpretation of recent statements concerning the manner in which the engineers of the Board of Water Supply prepared their figures for the Ashokan work.

Electrical Supply Rates.

Judging from the trend of attempted legislation there is still in the public mind an extraordinary lack of appreciation of the conditions which have to be taken into account in arranging an equitable schedule of electrical supply rates. It may therefore be not without value here to set forth some of the facts in the case, not so much for the instruction of the generally well informed readers of this paper, as to set before them the situation in view of their civic duties, which should tend to secure the square deal for all parties concerned. To begin with, electric service unfortunately is measured in terms which are strange and intricate to the ordinary consumer. If one could buy current by the quart or pound it would seem much simpler, and disputes would be fewer. But the kilowatt-hour is far less comprehensible, and is the source of misunderstandings. Another fertile source of trouble is very widespread ignorance of the cost of furnishing electricity. This is in no small measure due to the very crude way in which costs from the engineering standpoint are generally stated. It has come to be the custom in comparing station performances to give the cost of current at the switchboard based on fuel and operative expenses alone. This figure is often down to 0.5 or 0.6 cent per kilowatt-hour, and the consumer who sees it jumps to the conclusion that the difference between this figure and the 5 or 10 or 15 cents per kilowatt-hour which he pays is clean profit screwed out of the public by a rapacious monopoly. If the allowance for fixed charges, upkeep and depreciation were added to the operating cost things would take on a different appearance.

In actual practice even the cost thus determined does not come anywhere near the actual cost of service, for the distribution and selling expenses are formidable additions, generally bigger than the production items, and sometimes very much bigger. An electric supply station suffers severely from inability to store surplus product in any very large quantities and therefore has to make the stuff about as it is required hour by hour. As a result the station and operating force has to be two or three times as big as would be needed for the average demand, and the distributing system has to contain an abnormal amount of copper. At 4 or 5 p. m. everybody wants current and the station is carrying all the load it can stagger under, while in three hours a large part of the machinery is shut down. On this unpleasant and costly necessity are based as a matter of commercial fairness the apparently intricate systems of rates in common use. The man who uses current for long hours and in liberal amounts can obviously be supplied more cheaply than the customer who takes no current when the station needs load and requires it at a time when increased demand calls for an increase of maximum capacity. The basis of rates is the very natural and entirely fair desire to give the consumer whose requirements are such that he can be cheaply supplied the benefit of the saving. The "flat rate" often advocated and unfortunately sometimes enforced hurts this whole class of consumers for the benefit of those who use current for brief periods and at relatively costly times for the station. And the fact that it does hurt the long-hour consumer may also tend to discourage him and to throw a still larger proportion of load into the maximum peak with a corresponding increase in the average cost of the product to the supply company.

There is perhaps no such thing as a perfectly logical system of charging which will take full account of all these things. All systems are necessarily more or less compromises between precision and simplicity. A simple discount for quantity is a first attempt at a rate system, but it is obviously unfair to the consumer who uses his quantity at a time when it can be and might properly be supplied more cheaply than to one who takes his quantity between 4 and 5 p. m. A common alternative is the so-called "stand-by" charge, in which there is a certain fixed rate per kilowatt of apparatus which the supply company must stand ready to operate on instant demand, plus a meter rate for the current actually used. This is fair to many consumers, but bears hard upon domestic lighting in which the total capacity is abnormally large compared with that which in practice is actually demanded. Similarly one may pick flaws in any system of charging ever devised, yet almost any system unjustly burdens fewer people than the flat rate which throws the burden of the short-hour consumer upon the shoulders of the long-hour consumer. One great desideratum in electric supply is bringing current down to a price which will enable it to be profitably used in many cases now impracticable, and about the only way in which this can be done is to adopt a system of rates that will not arbitrarily discourage so many consumers as to hinder production and distribution on an increasingly large scale. It is especially unfortunate when State or municipal regulation of rates produces this result, for the proper purpose of such regulation is to secure reasonable rates to all consumers and not merely to particular classes, which is the uniform effect of such attempts. If State regulation is tried it should be directed to an intelligently devised schedule that will enable consumers to receive the maximum benefits without inflicting quite needless injuries on the supply stations.

Payments for Contract Extras.

It is the clear purpose in the preparation of any well-considered contract specifications so to cover the proposed work as to include all parts of it, and thus to avoid the disputes or contested claims which characterize the completion of nine contracts out of ten, or perhaps ninety-nine out of every hundred. The specifications are intended to be so complete as well as so discriminating as to show what must be done, not only in connection with the main features of the work involved, but also as to any preparatory operations, so that the contractor shall be in no doubt as to what he is to be paid for the direct work of the contract and for any preliminary or preparatory construction, if there be any. In spite of the most scrupulous consideration by the engineer of every provision of the specifications, it will be invariably found, if the work is of sufficient magnitude to include a variety of operations, that when it is completed there is enough doubt either as to the character of some of the work done, or in the language of the provisions covering its performance, and in the items of payment relating to it, to open the way for extra claims on the part of the contractor and for contesting their payment on the part of the engineer, both, it may be assumed, acting in good faith.

The purpose of the engineer is, or ought to be, to provide for his client a reasonable and economical construction, as expressed by plans and specifications fully and clearly enough to enable any competent contractor to ascertain just what he is expected to do in every particular, should the contract be awarded to him. Yet it is not uncommon even at the present time to find a kind of blanket provision in specifications as to some portions of the work, the character or amount of which is indeterminate, or perhaps about which there is much doubt as to its being required at all, and under which provision the contractor must actually make a gamble as to what such a feature of the work is to cost him. Consequently he must either take his chances on escaping the work or name a high price for a large profit. Fortunately for the construction of large works at this time such uncertain contract provisions are not so frequent as they once were.

It is reasonable to assume that a reputable and experienced contractor makes his bid in good faith and intelligently, and yet such a contractor will find himself much at sea in attempting to fix prices for items or features of construction like those just described. It is not surprising that in the execution of such portions of the contract conditions should arise quite different from those either named in the specifications or anticipated by either the contractor or the engineer, nor is it at all remarkable that the contractor and the engineer should take distinctly different views as to the proper payment to be made to the former. Although not specifically so stated in the specifications, neither party in interest pretends to gauge the hazard; both tacitly recognize it and the engineer plainly warns the contractor that it exists, but practically intimates that the contractor must determine for himself its character and amount and take his chances as to a loss or a profit. This is obviously likely to lead to a costly issue for the owner. As already observed no contractor can afford to gamble for a loss. If he is going to gamble at all, he will inevitably take his chance for the largest profit possible, and in doing so he is simply following the dictates of prudence. Furthermore, the very existence of these doubts, and the lack of clearness in setting forth precisely what is to be done afford just the opportunities which a shrewd contractor can easily turn to serve him as a basis for plausible claims for extras. When the plans and specifications show or express with clearness all the items of work to be done, the latter are outlined with precision and accuracy, effectively preventing any claims for extra work. It follows from this, what is otherwise equally clear, that an engineer's duty is to delimit completely every part of the contract field. No contractor is unreasonable in setting up an extra claim for work which is not plainly covered by the items scheduled in his contract, and in the final settlement experience has shown that he can collect in court a fair compensation for such work.

These observations are applicable to a far greater number of contracts than is ordinarily supposed, although fortunately they are becoming less applicable as specifications are more carefully written and as unit price contracts displace those which provide for lump sum payments. On the other hand, the greatly increasing magnitude of structural work and the necessarily more elaborate character of the contracts required for their construction, make it more difficult in a number of ways to eliminate contractors' claims for extras. At the present time these great contracts frequently call for an extraordinary amount of work of considerable variety for the installation of the contractors' plant. Any one of a number of large contracts in various parts of the country, such as a great irrigation reservoir, a modern high masonry dam, or even a great bridge, may necessitate the construction of a contractor's railway or the excavation and grading of a great yardage of material for the installation of crusher and power plants, storage or fabrication yards, and other similar purposes. While it may appear sufficient to warn the contractor to make a complete examination of the vicinity and form his own estimates of cost, as no allowance will be made for any part of the installation of his plant, there may be occasions where such a procedure is not advisable. It is by no means unheard of that the precise location of a great work may be somewhat changed at the last moment, and enough to demoralize materially a contractor's estimate of this part of his cost. It is not unreasonable for him under these circumstances to claim compensation for his increased cost of installation.

There obviously may be danger in the owner assuming the expense of a contractor's installation; in fact, that procedure, as a rule, is certainly to be avoided. At the same time, where there are such items as large quantities of excavation or well-defined classes of construction, all of which are capable of complete control by the engineer, it may be best to include them under suitable items in the contract. All possible claims for extras would be avoided, and in at least some cases decided advantages would be attained. In this, as in every other item, the specifications should make clear just what is allowed. There has also been no little difficulty experienced in connection with specifications in which the full application of some one payment item has not been clearly indicated. Wherever there is obscurity of language or of definition the contractor is put into a position of doubt as to what is required of him. Under those circumstances, the engineer has failed to make clear his requirements and the contractor can scarcely be considered unreasonable if he makes claim for extra compensation for something done which it cannot be conclusively shown he was required to do.

Power Plant Reconstruction.

In considering questions of power plant development the problems of reconstruction take an important place. The expansion of modern installations along the lines upon which the plants were first built is a comparatively simple task, provided the space available for enlargement is not too expensive to warrant the use of the same general type of machinery in the old and new portions of the buildings. A considerable number of steam-engine plants have been expanded by the installation of turbines on account of the capacity advantages of the latter type of prime movers in relation to their floor space, but it is still common practice to extend stations on the repeat-order plan in cases where the land is available at a feasible cost. Issues of this kind are fairly well defined as a rule, but when one faces the problem of remodelling an old station against building an entirely new plant on a separate site, the difficulties of arriving at a close solution are far from trifling. Questions of this character are particularly prone to come up in the newer sections of the country, and the South at present provides a number of illustrations of plants which were originally built at a fairly moderate first cost to operate the railway, lighting and power service of relatively small cities and towns; but which now need to be replaced by more modern equipments on account of the rapid growth of the communities supplied and the pressure of lower rates which inevitably tends to force down the cost of operation in order that reasonable profits shall be maintained.

The cost of reconstructing an old plant is inevitably high, and in most cases a longer time is required to handle such work than in building new plants of like capacity. Estimates can be readily prepared nowadays for the cost of building complete new stations, and the figures can be relied upon if they are put together by responsible engineers. In reconstruction work, however, the conditions of each problem are so peculiar to the local situation that it is an exceedingly difficult task to prepare an estimate of the cost of remodelling that will be a proper basis for the decision in favor of or against a complete new station. The problem must be attacked in plain view of the facts that the original service must not be impaired during the process of alteration—which generally means operating for many months at poor station economy—that the removal of obsolete and inadequate equipment is almost certain to disclose hidden conditions in the station construction which are so out of harmony with present-day requirements that further alterations will have to be made before the new equipment can be installed; and that unless the old apparatus is sold as it stands it is entirely possible that its second-hand value will be less, exclusive of the cost of removal, than in its original location. Unless actual bids are secured covering the cost of removal, or estimates are carefully put together on the strength of previous experience as to the time, material and labor required, with a liberal allowance for contingencies, the chances are that a mistake will be made in elaborately remodelling an old plant unless the conditions of site, fuel and water supply clearly indicate the wisdom of reconstruction on the original location. If space exists for the extension of the original equipment, the work of reconstruction can frequently be better handled, but it is important to go over the points at issue very carefully before deciding to add a modern high-powered generating unit with its necessary boilers and auxiliaries to a station containing a large proportion of old apparatus of doubtful efficiency and small capacity.

In the case of one plant recently examined a complete remodelling was under way in the face of conditions which clearly indicated the difficulty of carrying out such work at low cost. The engines were located on two different levels, the boilers were not in the proper places for the completed layout, the piping and foundations were in process of rebuilding, and the station output was costing close to 2 cents per kw-hour, exclusive of maintenance. Shortly before the work of reconstruction had been taken up, a new 1,200-kw. generating unit had been purchased at an unduly high cost by the company on its own responsibility, and the addition of this machinery to the plant definitely committed the project of reconstruction to remodelling on the original location. It is probable that had the problem as a whole been considered with regard to the influence of a new unit on the situation, a decision would have been reached to build on a new site, which could have been secured in this particular case at reasonable expense and with excellent condensing and coal facilities. Unless a very wide margin exists between the estimated cost of reconstruction and the cost of a new installation, the operating company certainly errs on the safe side in cutting loose from the old plant, except in cases where the distribution economy would be jeopardized by removal to a new location.

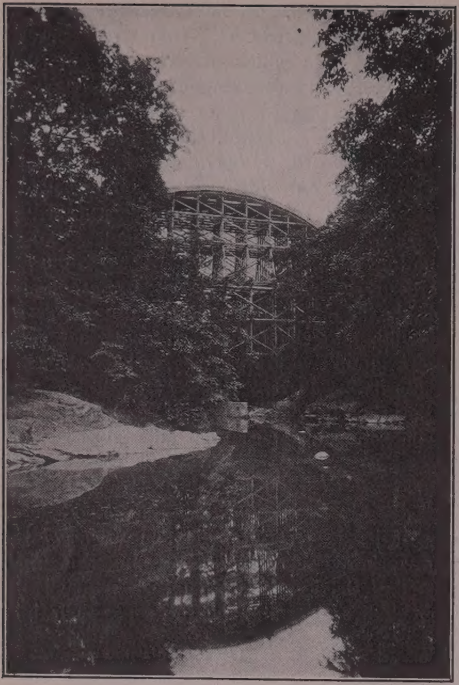
The depreciation of old equipment while the process of remodelling is going on sometimes occurs at a rate which extends the scope of the entire work beyond the original calculation. Another point which militates against the lasting economy of a mixed installation of modern and old apparatus is the difficulty now and then found in operating such equipment in multiple. Flexibility is hard to secure when the equipment is not homogeneous in capacity and general design. A final point in favor of constructing a new plant unless the rebuilding of the old installation is an undoubted financial saving of liberal size, is the advantage sometimes available in retaining the old equipment as a reserve. In one recent instance of this kind, a plant built about 15 years ago was held in reserve about 500 ft. distant from a new station of larger capacity. By carrying the load on the new station a saving of over $1,000 a month was effected through labor and fuel economies. If an attempt had been made to remodel the old station, it would not have been possible to secure the necessary capacity without a costly change of apparatus type, and even then the space would have been too limited for the best operating success.

Notes and Comments.

State Highway Construction in New York has received considerable criticism of late and as a result the Legislature appointed a committee at its last session to investigate such work. It submitted a report on the subject on Feb. 6, in which a number of recommendations are made, some of them of a radical nature. It is recommended that all the existing highway laws should be recodified into one statute, and all existing laws be repealed. Four systems of highway construction are recommended, two of them to be the present Higbie-Armstrong and Fuller-Plank systems and two of them entirely new plans. The first is the construction of 35 trunk highways connecting the large cities of the State, the work to be done entirely at the expense of the latter. At the present time no State funds are granted for such work unless the counties and towns through which the road runs pay a share of the cost. The other new system advocated is what is known as the French plan, which provides for the construction of purely local roads, the expense to be borne by the counties and towns solely. It is further proposed to take the supervision of the work out of the hands of the State Engineer and place it under the charge of a department of highways, consisting of three members appointed by the governor. The maintenance of State roads, it is further proposed, should be largely met by a tax upon automobiles. There can be no question about the desirability of a recodification of the various highway laws, but whether the State is ready to undertake the construction at its sole expense of through highway lines is problematical, and it is also difficult to see just how the State can force towns and counties to construct roads when they do not wish to do so.

High-Tension Direct Current for electric traction has been receiving much attention abroad, where some interesting work has recently been done with it. At the Preston works of Dick, Kerr & Co., tests have recently been made with a specially designed blow-out coil 6½ in. in diameter to which direct current at 3,200 volts was applied, with twelve 40-h.-p. 500-volt railway motors connected two in parallel and six in series in order to give an induction discharge similar to that which would be produced by two 175-h.-p. 1,500-volt motors in series. A current of 75 to 100 amperes was broken several hundred times, but hardly any trace of wear could be detected on inspecting the contacts. The results were so successful that an equipment for 4,000 volts direct current is now being built by the company mentioned, this to consist of two motors each of 1,900 volts, but capable of working up to about 2,000 volts and about 200 h.-p. capacity each. These will be connected permanently in series to allow for a line voltage of about 4,000. While this work is in a sense experimental, it nevertheless may be considered the final step proving the practicability of high voltage direct-current railway operation in heavy electric traction and consequently deserves the most careful consideration. The high-tension direct-current roads in Europe have recently been increased by the construction of one from Lucca to Monsummano, in which the wire tension is 850 volts. This is the maximum now employed in Italy for traction purposes, for the line from Castellamare to Sorrento, which previously held the Italian record, is operated with a line tension of about 800 volts. Attention is called to these advances because it was but a few years ago when engineers were taught that the voltage limitations of direct current for traction purposes had been reached. Mr. Frank J. Sprague was probably the only eminent electrical engineer who was willing to claim five years ago that direct-current motors would prove a serious competitor of alternating-current motors for heavy work. At that time he was more or less criticized, but it is unquestionably true that the direct-current motor is now receiving more and more attention on account of the gradual overcoming of one obstacle after another which has stood in the way of its successful application to heavy traction work over long lines. It might be added that the Belgian State Railways have just adopted direct-current apparatus for their initial electrification near Brussels.

The Business Side of Engineering was the subject of an earnest and forceful address by President Alexander C. Humphreys before the annual meeting of the alumni of Stevens Institute on Feb. 4. He has had so much success with his course in the economics of administration at the Hoboken school in the last five years that he now wishes to obtain an endowment of $100,000 for the permanent support of instruction along that line. The subject was brought up at a timely moment, for newspapers have lately been calling attention to a controversy between Andrew Carnegie, supporting engineering education, and R. T. Crane, who has been attacking it. In one sense President Humphreys supports Mr. Crane, for he stated that in his opinion a man with a low amount of technical information and high executive efficiency will be a better average assistant than one with a high amount of education and low ability to apply his knowledge. He pointed out, however, that the question was not so much with these individuals who have a small amount of knowledge or of practical ability, but rather with the average student, whose technical education proceeding along both scientific and economic lines, will bring him up to his maximum possible efficiency both as an engineer and an administrator. As a whole, President Humphreys' address was an appeal for a broader and at the same time more practical and thorough education for the young engineer; the fundamentals of engineering science to be taught with the greatest thoroughness; the ability to analyze data and to reason correctly from them to be cultivated rather than the memorizing of figures and formulas. The suggestions of President Humphreys are well worth considering in connection with the demand that the young men who enter technical colleges must be prepared by previous training to carry on in a fairly efficient manner the studies which are properly included in the curriculum of these institutions. An examination of President Humphreys' manual of business methods and an investigation of the instruction in book-keeping given in our best high-schools will inevitably suggest the possibility of requiring for admission to a technical school at least some knowledge of the simpler features of ordinary accounting. This information is taught to boys of 14 to 18 years of age in high schools and academies, and as such information is useful to most engineers, why not require it for admission to a technical college, instead of studying it there to the detriment of studies of a more advanced nature?



Falsework and Main Arch Rib.

Progress on the Walnut Lane Bridge, Fairmount Park, Philadelphia.

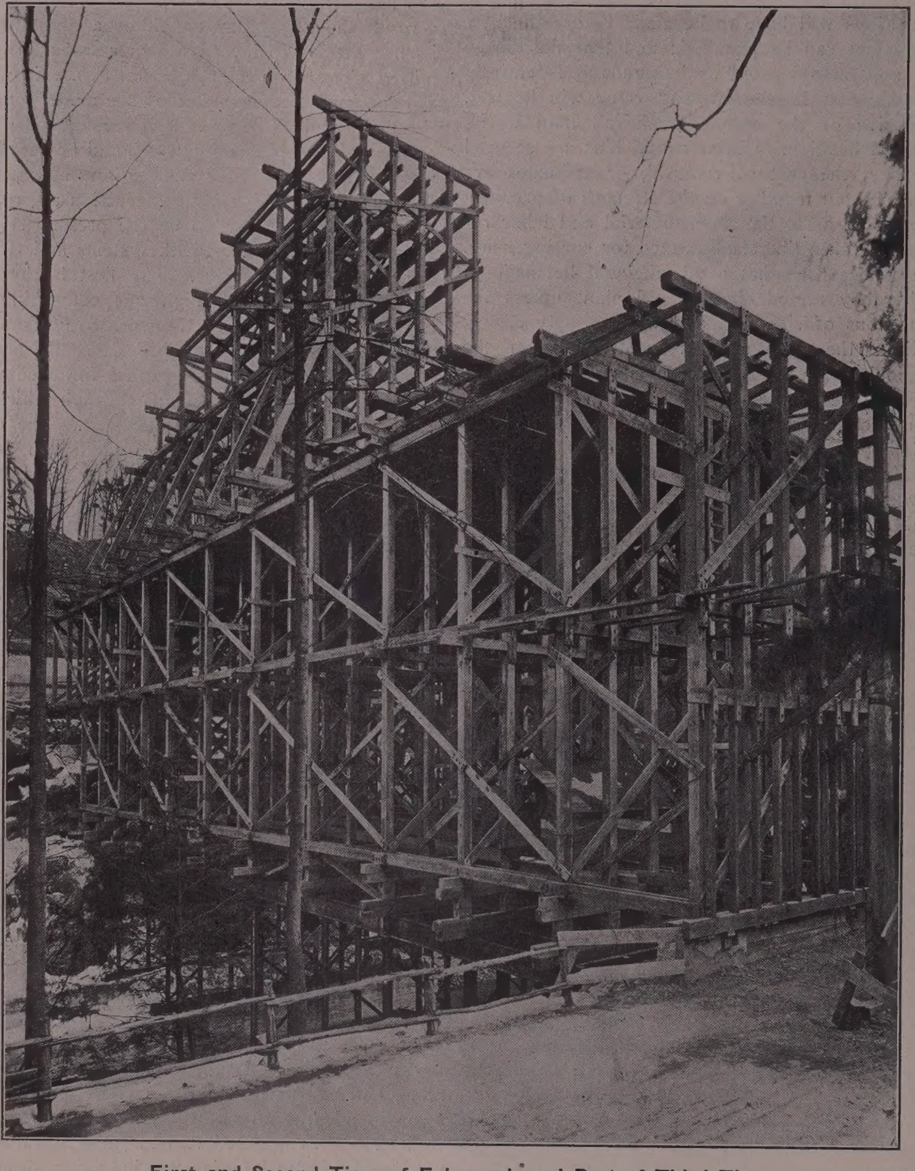
Construction is now far advanced on the longest concrete arch in the world, that of 233 ft. clear span across Wissahickon Creek, on Walnut Lane in Faimount Park, Philadelphia, which was illustrated in The Engineering Record of Nov. 17, 1906, and Aug. 31, 1907. The latter article describes the plant installed by the contractor and the method of construction employed for the first of the two parallel arch ribs of the main span and for the approaches. Since then the second arch rib has been completed, careful measurements and important observations have been taken on both arch ribs and considerable progress has been made on other parts of the superstructure.

The bridge is entirely of rubble or bastard concrete without reinforcement, and is 585 ft. long, 60 ft. wide, and carries an important thoroughfare through the park at a height of 150 ft. above the water. It has one 233-ft. main span with a 70-ft. rise, and five 53-ft. side spans. All spans are made with two separate twin ribs 18 ft. wide and 16 ft. apart in the clear. The radial depths of the main arch rib increase from 5½ ft. at the crown to 9½ ft. at the skewback, and each rib is made with 22 long voussoirs or sections and 17 keys. The ribs carry transverse vertical walls and piers supporting 20-ft. clear spandrel arches, which, in turn, carry longitudinal concrete walls on which the roadway platform rests.

The 53-ft. approach spans have monolithic arch rings with radial thickness varying from 27 in. at the crown to 42 in. at the skewback, and support longitudinal spandrel walls similar to those of the main arch. Horizontal transverse I-beams 20 in. deep and 6 ft. apart are carried on the tops of the spandrel walls and support the concrete jack arches forming the floor platform, which is uniform over the main and side arches. The total amount of concrete in the main span, exclusive of abutments, is about 6,500 cu. yd. In each rib it is about 1,700 yd., and each rib with its spandrel walls and spandrel piers contains about 2,400 cu. yd. of concrete and imposed a maximum load of about 5,000 tons on its falsework.

The main ribs were constructed on falsework built in three tiers. Four temporary concrete piers 12 ft. high and 85 ft. long were built in the bed of the creek with their foundations carried down to solid rock. On them were seated transverse steel bents 50 ft. long and 20 ft. high, without longitudinal bracing, which received 10 lines of deep longitudinal I-beams and with them form the first tier, supporting the center part of the second tier, which was of ordinary wooden trestle construction 232 ft. long, 42 ft. high and 30 ft. wide, made with two-story bents with ten 10 x 10-in. vertical posts in each. The upper tier, 30 ft. wide and 54 ft. in maximum height, has 15 transverse bents each, with six vertical posts from one to three stories high and two one-story batter posts in each.

All timber bents were well X-braced longitudinally and transversely and the 1½-in. planed transverse lagging was carried on 6 x 18-in. longitudinal timbers 12 in. apart, dressed to the curve of the arch. After the completion of the first arch rib the entire steel and wooden falsework structure, having an estimated weight of about 900 tons, was jacked transversely 34 ft. in three days and the upper and lower tiers were wedged up to position to receive the second arch rib.



First and Second Tiers of Falsework and Part of Third Tier.

The steam power plant and concrete mixer were located at roadway level near one end of the bridge, and the concrete was delivered as required in 1-yd. steel dump buckets operated by a 785-ft. cableway, which was twice moved transversely during the progress of the work.

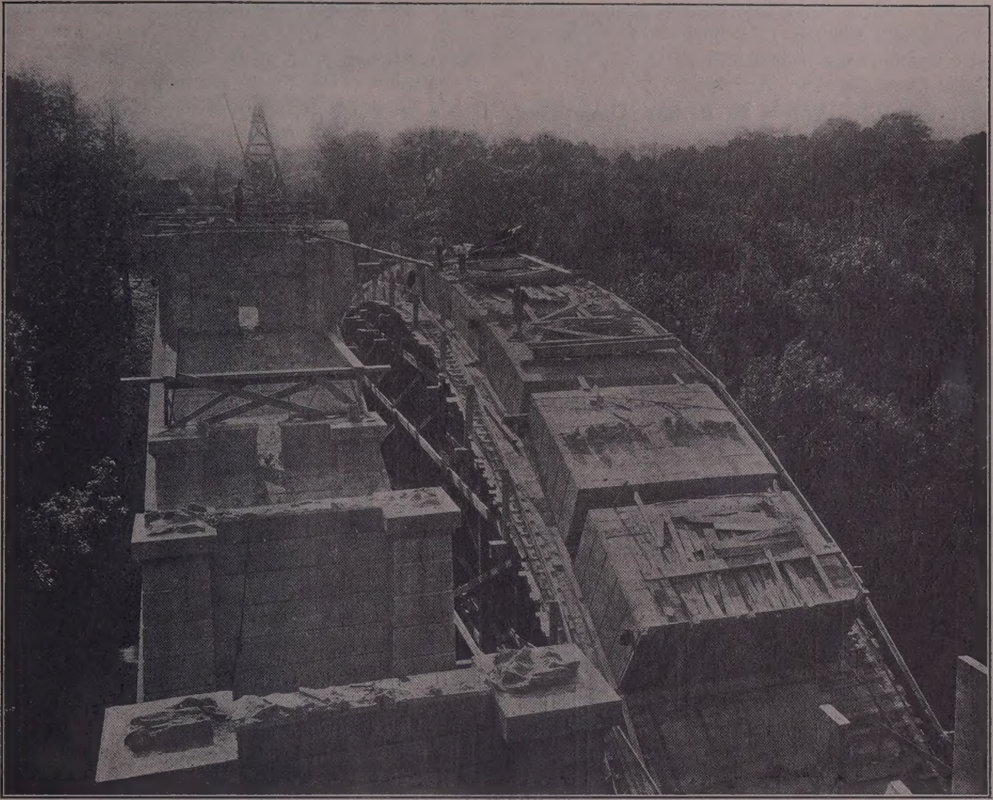
The concrete for each arch ring was cast in voussoir sections of the full depth and transverse width with lengths varying from 8 ft. 3 in. to 12 ft. 4 in., embracing from 4 to 7 voussoir markings each, and weighing as much as 170 tons each, and were built simultaneously in pairs in symmetrical positions on opposite sides of the center of the arch. After all of the sections were completed, the 17 single voussoir spaces between them were filled with concrete, keying the whole together. Afterwards the transverse spandrel walls and spandrel piers were built before the centering was struck.

The construction of the falsework was commenced last winter, concreting the voussoirs of the first rib was commenced April 29, and the keying was finished June 16. The wedges were struck July 22, and the falsework was moved forward into position and ready for the construction of the second arch rib on Aug. 2. Concreting the voussoirs of the second rib was postponed until the approach arches and spandrels of the south line were completed and the cableway moved to serve the north line. It was commenced Sept. 16 with two 6-men gangs working simultaneously on the opposite sides of the center.

On each of the 22 principal sections of the arch rings work was maintained continuously from the time it was commenced until it was finished, usually about 8 to 13 hr., and after they had been completed they were permitted to set for about two weeks before keying. The 17 intermediate voussoirs or keys were cast in 3 days, being completed Oct. 17, the actual working time on the whole of the north rib being only 15 days in all, and the elapsed time from beginning to finish, including bad weather, Sundays, holidays, and the seasoning of the main voussoirs, thirty-one days.

In order to swell the falsework bents and blocking as much as possible before keying, water was applied to them through a 1½-in. pipe under

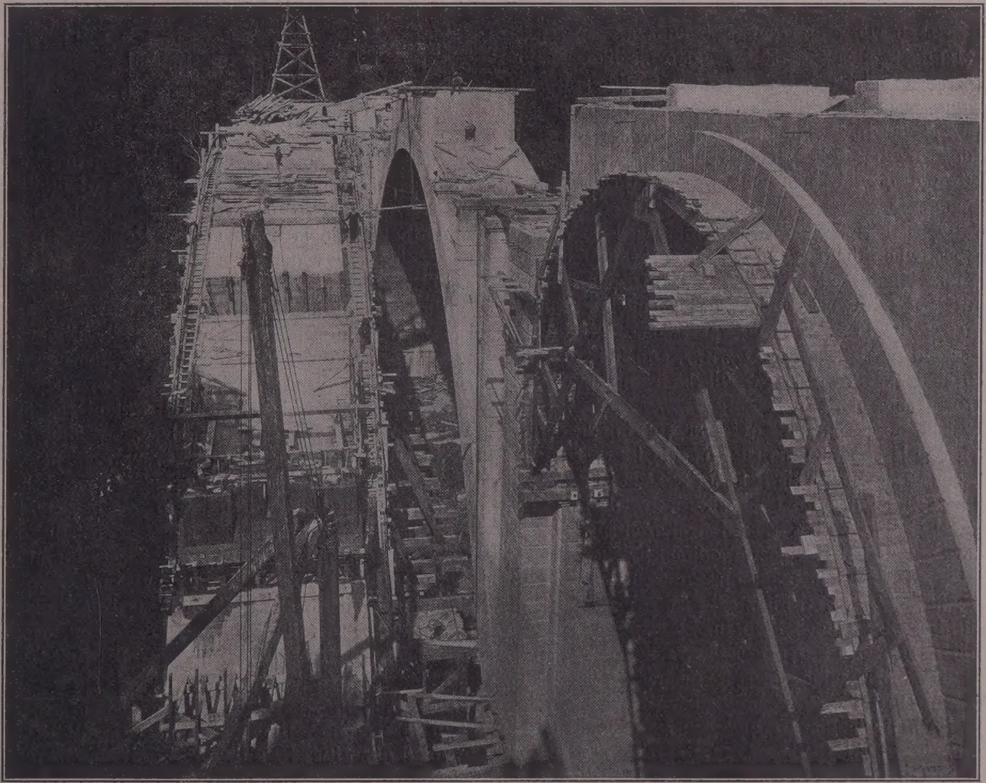
75-lb. pressure and a branch at the center of the main span had a 1-in. outlet on each side of the arch rib through which the water was allowed to flow freely on the surface of the lagging for three days before the keying was commenced. The stream thus provided flowed with considerable uniformity over the convex surface of the falsework and in the plane of each vertical bent a portion of it was diverted through a small hole by an inclined cleat nailed to the lagging, which provided for a small stream flowing over an inclined trough which distributed a constant supply to each of the vertical posts in the bent.


First Main Arch Rib and Spandrel Piers Finished; Second Rib Nearly Ready for Keying.

The falsework timber was thus thoroughly saturated and swelled up to slightly increase its height and provide for gradual release of its load through shrinkage in drying. The water supply was cut off as soon as the keying was accomplished and the timber gradually dried and shrunk simultaneously with the shrinking of the concrete due to the setting of the latter. Although the shrinkage was not great enough to open up a crack between the lagging and the arch rib, it was undoubtedly great enough to relieve the falsework from some of the load, and provided a very delicate method of gradually transferring a portion of the dead load of the arch rib from the falsework to the concrete, thus slowly developing a portion of the dead load stresses in the latter.

The centering was struck Dec. 27 by a force of 12 men in two gangs driving out the wedges between the upper tiers of falsework. Between the caps and sills in each transverse bent there were ten pairs of oak wedges, one pair on the center line of each of the lower vertical posts. The wedges were 10 in. wide and 20 in. long, tapered from 3 to 6 in., and planed very smooth on both faces. In many cases the wedges were easily driven out by two men for each pair, one man on each side of the bent with a sledge hammer. The driving of some was so hard that it was necessary to first release the wedges a little by a 15-ton jack placed midway between two adjacent pairs of wedges. In a few cases a jack was placed close to the wedges on each side. In two cases even this did not suffice, and it was necessary to split out the blocking because the sledging did not start the wedges. The centering was lowered free of the arch rib in six hours by eight men with sledges and four men operating and handling the jacks.

After removing the wedges the rib settled about ⅛ in. at the crown and a little less at the quarters, an amount corresponding closely with that observed for the first rib. The drying and shrinkage of the centering permitted a very small deflection in the arch ring which kept the voussoirs in bearing on their joints. The shrinkage of the centering was demonstrated by the fact that although the temperature of the atmosphere fell considerably between Oct. 16 and Dec. 26, when the wedges were driven out, there was absolutely no sign of opening in any of the joints between voussoirs. The temperature fell 10 or 15 deg., producing a calculated contraction of ⅜ in. or 9/16 in. in the length of the arch ring, the curve of which is such that the drop at the crown is equal to the shortening of the arc of the ring.


Casting Voussoirs of Second Main Arch Rib.

As there are in the ring 17 keys, each of which is subject to some shrinkage, there must be at least 17 radial joints absolutely without any adhesion of surfaces. If the centering had not shrunk with the shrinkage of the arch concrete, but had remained fixed and had supported the whole weight of the arch ring, each of the 17 free joints would have opened one-seventeenth of the total shortening of the ring, but none of them shows even a hair crack.

The fact that no joints in either arch rib is opened at either the extrados or intrados proves that the line of pressure certainly falls within the middle third. As the arch ring is built entirely without reinforcement and the keys were subject to some shrinkage, however slight, there is constituted an absolutely dry voussoir arch ring having no tensile value at any joint.

After the completion of the south ribs and spandrels the cableway was moved transversely 34 ft. to the center of the north ribs, and after the completion of the latter it was moved back 17 ft. to the axis of the bridge to be used in the removal of the falsework, which is now in progress. This removal is being accomplished by tilting and laying flat each bent and dismembering it.

When the concrete piers for the steel falsework bents were built small chambers were left in the lower part and were provided with flues or openings temporarily closed. After the falsework is removed these chambers will be filled with dynamite and it will be fired, destroying the piers and reducing the concrete to small pieces, which will be dredged out of the river bed and used for fill at the ends of the bridge.

Work on the floor platform has been commenced at one end of the bridge, where a length of about 60 ft. has been completed over one of the approach spans, where the same method has been employed that will be used throughout the bridge. The longitudinal spandrel walls in the approach span have been built and the transverse spandrel walls and piers have been built in the main arch rib and are now ready to receive the 20-ft. longitudinal spandrel arches, which are all that must yet be done to complete the construction up to floor level. Each of the spandrel arches will be built on lagging carried by four trussed centers with their ends seated on transverse horizontal double-sills carried on the 6-in. projecting belt courses at the tops of the spandrel piers and provided with 6-in. wedging clearance. In making these offset mouldings or capping courses care was taken to have the large embedded stone project into the offset to secure as high shearing value as possible.

The centering for the jack arches between the floor beams is suspended from the latter by means of ¾-in. steel U-bolts saddled on blocks over the top flanges and with their screw ends engaging cleats below the centering. After the concrete is sufficiently seasoned the nuts are removed and the bolts withdrawn from above.

All the showing surfaces of the bridge, except the soffits of the arches, are finished by the Quimby process, which consists of removing the forms while the concrete is still friable and washing it with water applied with scrubbing brushes. This removes the film of cement which segregates against the forms and exposes the clean sand and grit of the aggregate, giving a surface stone-like in color and texture. The soffits of the arches, which, of course, cannot be uncovered in time to be washable, are bush-hammered to remove the impressions of the lagging boards and expose the grit, matching as nearly as possible the side surfaces. This bush-hammering is done with pneumatic tools, one man finishing from 150 to 200 sq. ft. per day.

The bush-hammering is done from a suspended scaffold. Horizontal 10 x 10-in. transverse beams about 25 ft. long are laid on top of the spandrel piers cantilevering 3 or 4 ft. beyond each side of the arch rib, and from both ends are suspended Manila tackles supporting platforms like a painter's scaffold. These are about 4 ft. wide and 20 ft. long, enclosed with guard ropes, and conveniently set at varying heights about 4 ft. below the intrados of the arch, thus providing working platforms for the men who operate the pneumatic hammers.

Construction work was commenced on Aug. 1, 1906, when the 6,000 cu. yd. of excavation was begun. The erection of the 370,000 ft. board measure, of falsework timber was completed April 1, 1907; the first arch rib was swung July 22, the second one was swung Dec. 27, and it is now expected that the bridge will be completed ready for traffic next June.

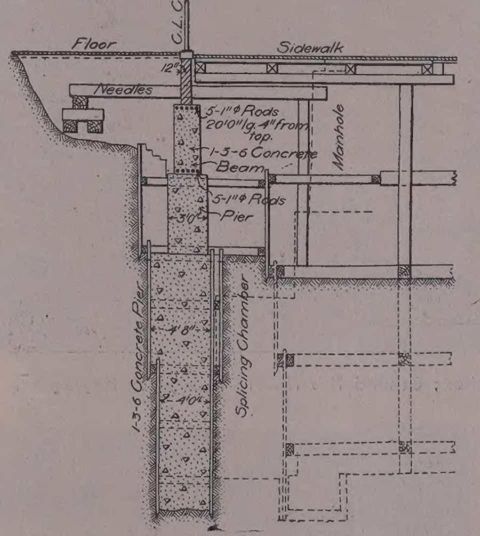
The total amount of concrete in the entire bridge is about 21,000 cu. yd., and its cost will be about $258,000. This is about $50,000 in excess of the estimated cost of the alternative design for a steel viaduct with a trussed steel arch span. If the present design had been modified by the substitution of cut stone voussoirs for concrete in the main arch, it is estimated that the cost of the bridge would have been increased about $50,000, on a basis of $30 per cubic yard for cut stone and $8 per cubic yard for concrete, a smaller yardage of the stone ring being admissible.

Both the engineers and contractors have been in accord in their efforts to secure first-class work and make the best possible structure. Inspectors were constantly stationed at the mixer and at each concreting gang, and 6-in. and 12-in. concrete cubes made from each day's output have been systematically tested in the city laboratory, which has facilities for testing in compression to 1,000,000 lb. Work has been conducted with an average force of about 125 men.

The bridge was designed and the method of construction prescribed and supervised by the Department of Public Works of the City of Philadelphia, Mr. Geo. R. Stearns, director, Mr. Geo. S. Webster, chief engineer, Bureau of Surveys, Mr. Henry H. Quimby, assistant engineer in charge of bridge division. The contractors are Messrs. Reilly & Riddle, and the supervision of the work is under the personal direction of Mr. T. H. Riddle. Mr. Moriz Bernstein is their engineer and Messrs. Chambers Lattimer and O. G. Hoover are assistant superintendents.

Timber Pile Protection in San Diego Bay.

The protection of the timber piles of wharves and docks in San Diego Bay against the action of limnoria is particularly difficult, owing to the existing conditions being so favorable to the growth of these wood-borers. This bay is an almost land-locked arm of the Pacific Ocean in the southwestern part of California, and receives a very limited amount of fresh water from the surrounding country. It is an important harbor and contains several wharves, docks and ferry slips. The timber portion of these structures that are submerged, if not protected fully against the limnoria, do not withstand the ravages of the latter more than two or three years. At the same time, the teredo is not specially prevalent in the bay, since the water of the latter is unusually salty.



Section of Underpinning Pier.

The piles of all the structures in the bay and the surrounding waters have accordingly been protected for several years. Essentially, the method of protection used consists of a covering of cement mortar, which is placed around the pile after the latter has been driven. While this method has been used widely in various places, the manner in which the mortar is placed has been given particular attention in this locality.

After various experiences, mortar consisting of 1 part cement and 2 parts sand has been found to produce the best results. Since the mixture of the mortar is much weakened in depositing it under water by ordinary methods, different means have been tried to secure the desired results, removable steel forms being used in all cases. As a development of these attempts, it has been found best to have the mortar placed in the forms in small quantities by a diver. While this method is expensive, it is the best one that has been evolved for providing the type of protection used.

The forms in which the mortar is cast are made of sheet steel in sections 18 in. long, each section being split longitudinally in halves. The halves of each section are reinforced at the sides with light angles, which form flanges that permit a tight joint to be made between the halves by means of rubber gaskets. These joints are necessarily made perfectly tight, since the slightest leakage through them greatly reduces the strength of the mortar. It has also been determined that clamps instead of hinges are required to produce a satisfactory joint, due chiefly to the rapid deterioration of the hinges in the salt water. The lower end of each 18-in. section is slightly reduced in diameter, while the upper end is hammered out to an increased diameter. This difference in the diameter of the two ends enables a tight sliding-fit joint to be made readily between the sections. The forms are made in two diameters, 19 and 22 in., one-half of a section of each size being used to produce a size between the two.

The diver is suspended in a gantry swung from a boat or barge. He places the first section of the steel forms generally in an excavation below the level of the bottom. Mortar is then lowered to the diver, in double-end scuttles holding about 2 cu. ft., who places it in the forms by hand. After each section is placed and filled in this manner, the suceeding section is set on top of it. The mortar is carried up to the mean-tide level, and the remainder of the pile painted with a wash of neat cement. Danger of the protection being split by the pile swelling is thus avoided, while the wash of neat cement applied in the open is a satisfactory protection against the wood-borers. The work is thus slow and arduous, but when properly done produces an even, uniform protection.

Experience in these waters has shown that the piles of a structure must necessarily be permitted to remain in the water several months before the concrete is applied, in order that the timber may be fully swelled. Owing to sandy bottom being scoured by changing currents and by a species of fish, which frequents these waters, it is also essentially necessary to inspect occasionally the bottom of the piles of a structure protected in this manner and to carry the protection down where scour has occurred. The protection of a pile is broken occasionally by impact from a vessel, but in such cases the film of cement which adheres to the wood when the mortar is placed is an adequate protection until permanent repairs can be made.

Most of the pile protection works in San Diego Bay and the adjacent waters has been done by Spreckles Bros. Commercial Co., under the direction of Capt. A. A. Polhamus, who first used this method in San Pedro harbor some years ago.

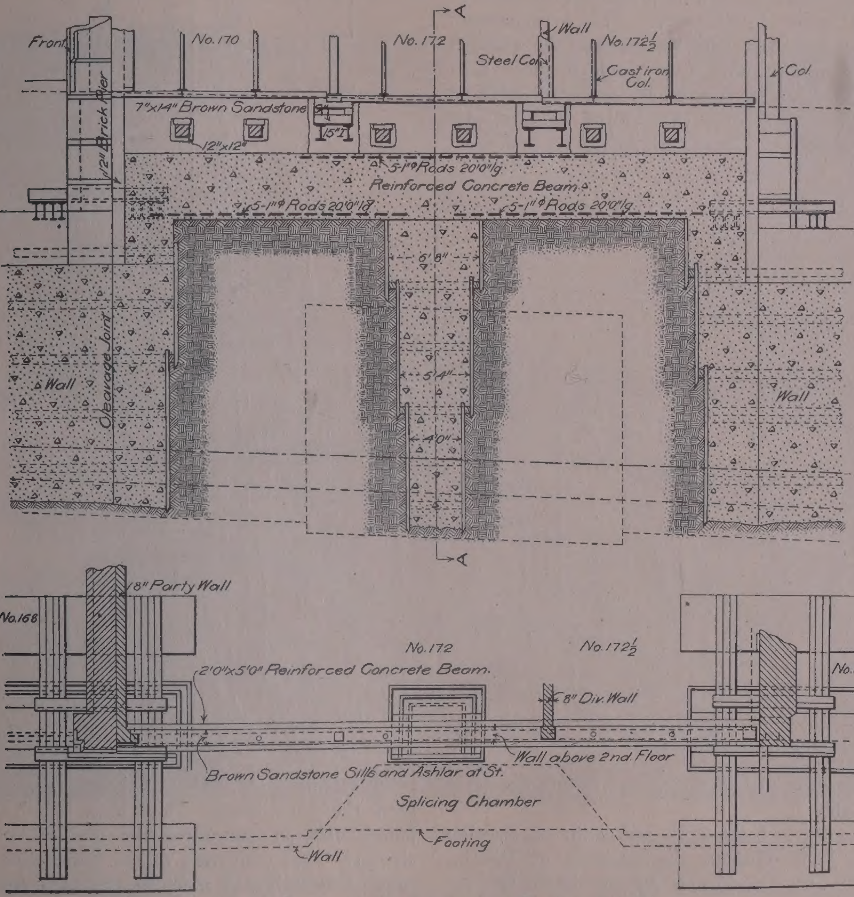
The Sewage of Hamburg, Germany, is turned into the River Elbe without treatment other than removing the grosser solids by screens. The water supply intake is only 6 miles upstream from the point of sewage discharge, but so far the dilution method of disposal has been satisfactory. According to a report by Mr. C. F. Wike, city surveyor of Sheffield, England, land has recently been acquired where a plant for further treatment will be erected if necessary. At present the whole sewage of the city, 29,000,000 imp. gal. per day, is passed through a large chamber, with a very elaborate system of screens worked on Brunottes' patent. The sewage is passed first through a large grid, with bars about 10 in. apart, into a tank where, as far as practicable, the sand and grit is separated from the liquid sewage and lifted by means of an elevator. The grit so removed is filled into trucks and dumped. The sewage then passes through revolving screens, consisting of aluminium bars about 0.6 in. apart. These catch the solid matters and carry them slowly upward from the sewage at a speed of about 1 in. per minute, depositing them upon traveling carriers which convey them to boats in the river. These deposits are eventually removed to an island and used for manurial and other purposes. The whole screening plant is electrically driven, and to a large extent automatic.

Supporting a Foundation Wall on a Reinforced Concrete Girder.

Among the buildings in danger of settlement or undermining by excavations for Bridge Loop for the subway system of the Public Service Commission of New York were three small three-story buildings at Nos. 170, 172 and 172½ Canal St. They have a continuous frontage of 48 ft., and the second and third story front walls are supported by second floor lintel beams carried on the party walls and on cast-iron columns with their bases seated on a continuous brick foundation wall 12 in. thick and 4 ft. high, which originally had a 12 x 24-in. stone footing. The subway excavation comes so close to the wall that in order to prevent danger of undermining or settlement it was necessary to carry the supports for the latter down below sub-grade. The building was, however, so light that it was unnecessary to provide a heavy continuous high footing wall for it and in order to economize excavation, sheeting, bracing and concreting, a plan was devised for supporting it on a heavy longitudinal continuous girder supported at the extremities on the new foundation walls for adjacent buildings and in the center by an intermediate pier.

The front of the building was accordingly supported temporarily on eight needle beams composed of single 12 x 12-in. timbers and double 15-in. I-beams 20 ft. long inserted in holes cut through the foundation walls in the vertical lines of the columns. Continuous lines of 8-ft. sheeting were driven by hand on each side of the wall, a trench was excavated under the whole length of the wall and the old stone and brick foundations removed. At the center point of the wall a pit was excavated 6 ft. 8 in. square at the top and 4 ft. square at the bottom, and carried down to subgrade of the subway with three sets of hand-driven sheeting. The pit was completely filled with 1:3:6 concrete, on which were supported the side pieces of a mould 5 ft. deep and 2 ft. wide which extended from end to end of the trench and rested at the ends on the already constructed walls for underpinning of the adjacent buildings. The mould was built without a bottom, the earth in the bottom of the trench being leveled and smoothed to receive the concrete, a 4-in. layer of which was spread in it and leveled. On this concrete, while still fresh, were arranged five 1-in. rods 20 ft. long, reaching from the intermediate piers to both ends, at each of which there was placed a set of three 15-in. I-beams 6 ft. long carrying permanent longitudinal needles made with 12-in. I-beams 10 ft. long to support the party walls of the adjacent buildings. The mould was then completely filled with concrete having corresponding 1-in. rods embedded in the upper part of the beam over the center pier. This affords abundant security for the wall, acts as a retaining wall and obviated considerable expensive work in excavation and sheeting.

The work was done with the approval of The Engineering Department of the Public Service Commission, Mr. H. B. Seaman, chief engineer, Mr. G. S. Rice, assistant chief engineer, and Mr. Geo. H. Clark, division engineer. The details were planned and the work executed by the contractors for this section of the subway, the Degnon Contracting Co., Mr. H. C. Sanford, chief engineer, and Mr. F. D. Fisher, engineer in charge.



Reinforced Concrete Underpinning Girder and Pier.

A SEVERE SERVICE TEST was imposed upon the 1,000-kw. gas engine generating unit of the Milwaukee Northern Ry. in a recent wind and snowstorm. In the effort to keep the line open, a large snowplow, a track sweeper and four city-type street cars were kept in operation in addition to three regular interurban cars, and this brought a very heavy fluctuating load on the single unit that is now operated. This is an Allis-Chalmers four-cycle double-acting twin-tandem gas engine direct-connected to a 1,000-kw. Bullock alternator and it carried a load that fluctuated from 280 h.p. to as high as 2,400 h.p., averaging close to its nominal rating. It is said to have operated very satisfactorily under these conditions, picking up the heavy loads with ease.

Flood Protection along Cherry Creek in Denver, Colorado.

Cherry Creek in Denver, Colo., is a tributary of the South Platte River and has its source in the foothills to the southeast of the city, the mouth of the creek in the river being near the central business district. As is common in most streams on the eastern slope of the Rocky Mountains in Colorado, the volume of flow in Cherry Creek varies greatly. During seasons of extreme drought no surface flow whatever occurs for considerable periods, while flood flows of great volume occur occasionally. The natural course of that part of the creek within the city was comparatively wide and quite irregular. Although the creek has an average fall of about 30 ft. to the mile, the valley is relatively wide and flat and is largely shifting sand containing some small boulders. The large volumes of water which the stream frequently carries, combined with the heavy fall and the nature of the soil in the valley rendered the control of the flood waters particularly difficult. In fact, until recently little attempt had been made to confine the stream except at the various bridges on which streets are carried over it, so considerable areas were subject to inundation. Consequently, the adjacent land on both sides of the creek was largely vacant, the result being that the territory in the vicinity was all seriously affected, although much of it is close to the business district.

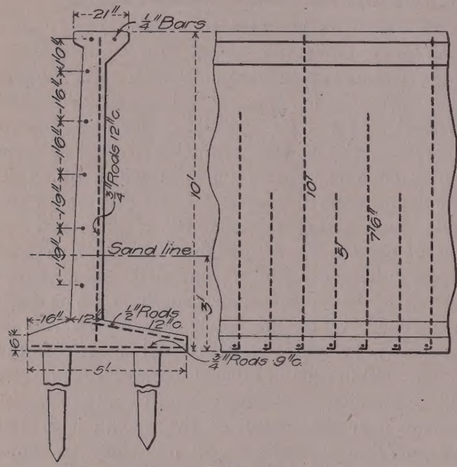
Improvements intended to relieve these conditions by confining the stream to a straight channel, even during maximum floods, were undertaken last year by the city and are being carried forward as rapidly as possible. Two continuous concrete retaining walls are being erected to form a new channel, with a uniform width of 80 ft. and a minimum depth of 8 ft. to the top of the walls, thus giving the channel a cross-sectional area of 640 sq. ft. A section of this new channel a mile in length has been completed, and a second portion of about the same length is to be built next year. When the work contemplated to be finished next year is completed most of the stream within the developed portion of the city will be confined, as some work in controlling the channel near the mouth of the stream had been done previously, and the two miles of new work adjoin the upstream end of this previous construction. A boulevard drive is being built along the new channel, so the completion of the latter not only renders available for occupancy a large area of waste land, but will also greatly improve the appearance of the surrounding district.

The reinforced-concrete retaining walls which form the sides of the new channel have a thin slab section, with buttresses on the rear face of this section tying the latter to a broad footing course. The walls have a uniform total height of 10 ft. above the footing course, except at one bridge, are 1 ft. thick at the base and 6 in. thick under a coping at the top, the rear face being vertical. The footing course is 6 ft. wide and has a minimum thickness of 12 in., the toe of the wall being 1.5 ft. back from the toe of this course. The buttresses are placed 8 ft. apart on centers and are 8 in. thick.

The reinforcement of the wall slab under normal conditions consists of longitudinal and vertical ½-in. bars spaced 18 in. apart on centers in both directions, the plane of the reinforcement being at least 1½ in. from the front face of the wall. The horizontal rods are in 32-ft. lengths and are lapped 24 in.; the vertical rods are extended to within 3 in. of the bottom of the footing course. The reinforcement of the footing course consists of longitudinal and transverse ½-in. bars spaced 12 in. apart longitudinally and 18 in. apart transversely, the longitudinal rods being in 32-ft. lengths and the transverse rods in 5-ft. lengths. The horizontal reinforcement in the buttresses consists of bars in the same plane as the horizontal bars in the slab section of the wall, three sets of three ¼-in. bars being used toward the top and five sets of five ½-in. bars in the remainder. A ¾-in. bar parallel to the rear face of the buttress extends from the top of the latter to the bottom of the footing course, and a ½-in. bar, 5 ft. 8 in. long, is also placed on about the same slope toward the middle of the buttress. The coping on top of the wall is reinforced with three ¼-in. longitudinal bars, provided merely for stresses due to temperature changes.

The buttresses are each on two piles where soft ground was encountered, as was the case in most places. Piles 10 in. in diameter at the butt and 10 to 18 ft. long were used. When fairly good foundation was found the buttresses were built on concrete piers carried to various depths, depending on conditions.

In order to provide protection against the walls being undermined on the channel side, the footing course was placed in a trench 3 ft. deep below the surface of the natural bed of the stream. Where the channel was in excavation the wall trench was made 8 ft. wide on the bottom and with 1 to 1 slopes on the sides. The channel excavation was also not carried down below a level 3 ft. above the bottom of the footing course. After the wall was completed it was back-filled up to this level on the channel side and up to within 1 ft. of the top of the coping on the rear side. The surface of the back-filling was continued level on that side back to the slope of the excavation. The wall trench was made of the same cross-section in embankment and was back-filled on the rear to within 1 ft. of the top of wall, the top of the embankment being made level for a width of 7 ft. on top and then carried down on a slope of 1½ to 1. It is expected, however, that the low ground in the vicinity will eventually all be filled up to, or above the level of the tops of the walls and utilized for buildings.

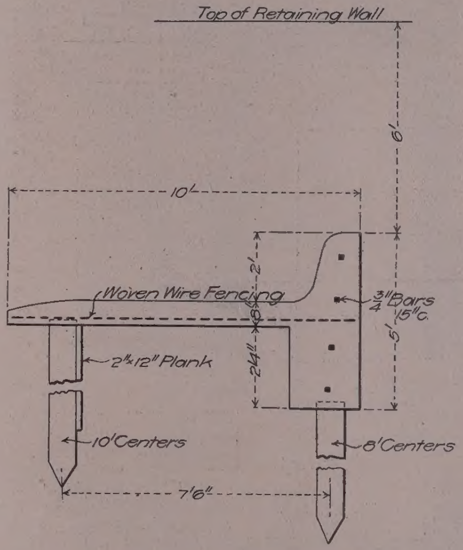


Proposed Wall Section.

Plans have been prepared for a wall of similar section to be used in the mile of channel work to be done next season, but this proposed section is to be reinforced quite differently from the one described. The details of the reinforcement in this section are shown in an accompanying illustration. The height of the proposed section has been reduced from 11 ft. to 10 ft. and the thickness of the wall increased to 8 in. at the top, as compared with the completed work.

The quantity of water flowing in the stream is generally not sufficient to cover the bed of the channel, and, as the stream passes through such a prominent section of the city, a quite unusual method has been adopted to overcome the unsightly appearance of the exposed stream bed. Low overflow dams, built of concrete, are placed across the channel at intervals of 300 to 500 ft., the spacing being such that each dam will back the water up to the one above it, thus forming a series of pools. The crest of each of these dams is 2 ft. above the bed of the stream and 8 ft. below the top of the walls. Four openings fitted with gates are provided in each dam, in order that the sand which settles against the dam may be flushed out. A wide apron is placed on the downstream side of each dam to protect the bed of the channel from wash, and the dam is carried 24 in. below this apron to prevent undermining. The dam section proper is on a row of piles 8 ft. apart on centers, and the downstream end of the apron is also on a row of piles, 10 ft. apart on centers. A vertical row of three 2 x 12-in. plank was placed against the downstream side of the row of piles under the end of the apron to cut off any wash that may come under the bottom of the apron.

Although the stream is practically dry at seasons, sufficient water is available to keep the pools filled and thus present a practically continuous sheet of water at all times. This arrangement, together with the boulevard along the channel and the ornamental bridges which have been built already, and are to be provided later to carry the streets over the stream, have greatly improved the appearance of the locality, without increasing the cost of the necessary improvements appreciably.



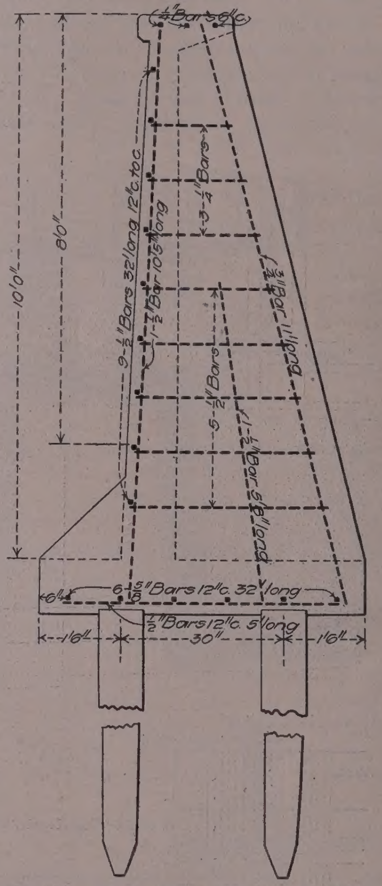
Overflow Dam, Cherry Creek.

The work is being done under the supervision of Mr. J. B. Hunter, city engineer of Denver, Mr. Geo. M. Post being directly in charge for the city. The Denver & Pueblo Construction Co., of Denver, had the contract for the wall construction that has been completed.

Tests of Air Leakage around windows were reported by Mr. H. W. Whitten at the recent meeting of the American Society of Heating & Ventilating Engineers. He has found that with a wind pressure equal to 0.1 in. of water outside a window having a 1/32 in. clearance between window frame and sash, 105 cu. ft. of air were driven per hour through each lineal foot of such clearance space, while with a 1/16 in. clearance, the leakage was 184.8 cu. ft. per hour. With other windows, equipped with good metal weather strips and subjected to the same pressure, the leakage amounted to no more than 12 cu. ft. per lineal foot per hour. In tests made with a pressure of ½ in. of water, which corresponds to a wind velocity of 24 miles per hour, leakages were noted of 179 cu. ft. per lineal foot for 1/32-in. clearance, 402 cu. ft. for 1/16-in. clearance, and 45.6 cu. ft. for the sash with the metal weather strips. With a pressure double that used in the latter case, equivalent to a wind velocity of 48 miles per hour, the leakages were 432 cu. ft., 591.6 cu. ft. and 69 cu. ft.

A Specification for Coal-Tar Creosote.

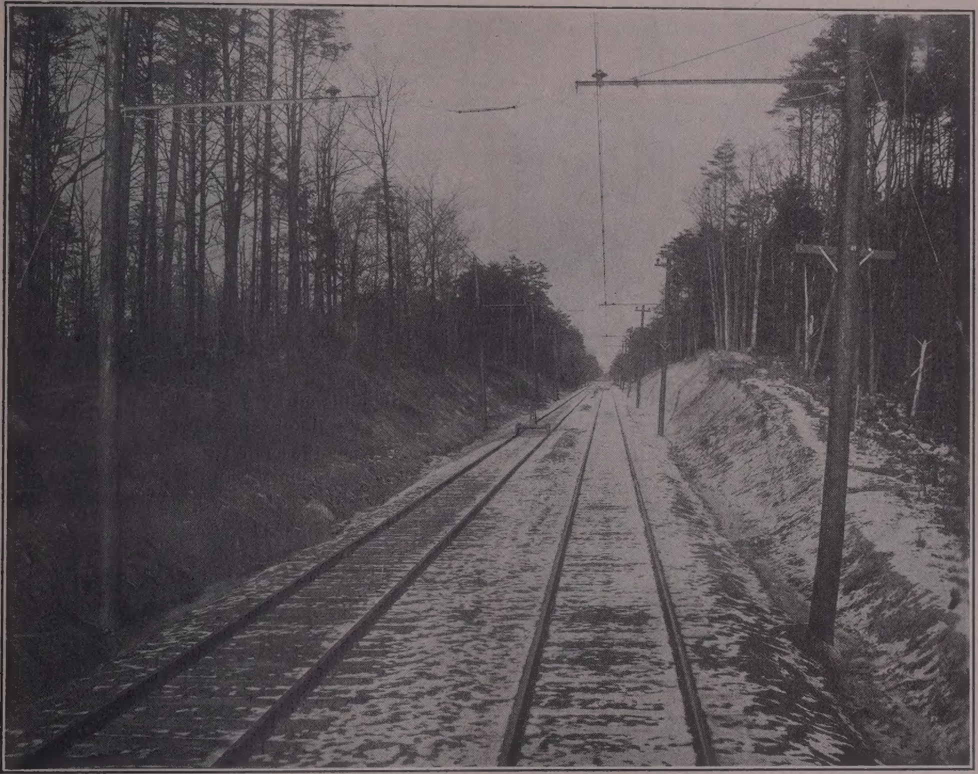
A specification for coal-tar creosote proposed some years ago by Messrs. von Schrenk, Fulks and Kammerer, is brought to attention by them in a paper in the November, 1907, Bulletin of the American Railway Engineering and Maintenance of Way Association, in connection with a discussion of the results of an investigation of the changes due to exposure in coal-tar creosote. The investigation led to the conclusion that the actual chemical composition of the constituents of a creosote oil is of minor importance in securing the indefinite preservation of timber, as compared with the constituents which have high boiling points and so guarantee the greatest possible stability. The reduction of the low-boiling fractions is desirable, as much as possible, consistent with obtaining an oil which will be fluid enough at all working temperatures. This the specification aims to secure, leaving out the question of the chemical properties of components, and dwelling upon the necessity for obtaining fractions of a high boiling character as determined by fractional distillation. The specification is as follows: "The oil used shall be the best obtainable grade of coal-tar creosote; that is, it must be a pure product of coal-tar distillation and must be free from admixture of oils, other tars or substances foreign to pure coal-tar; it must be completely liquid at 38 deg. Cent., and must be free from suspended matter; the specific gravity of the oil at 38 deg. Cent. must be at least 1.03. When distilled according to the standard method, that is, using an 8 oz. retort, asbestos covered, with standard thermometer, bulb ½ in. above the surface of the oil, the creosote, calculated on the basis of the dry oil, shall give no distillate below 200 deg. Cent., not more than 5 per cent. below 210 deg. Cent., not more than 25 per cent. below 235 deg. Cent., and the residue above 355 deg. Cent., if it exceeds 5 per cent. in quantity, must be soft. The oil shall not contain more than 3 per cent. water."



Section at Buttress, Cherry Creek.

The Washington, Baltimore & Annapolis Electric Railway.

Car service was begun last week on a portion of the Washington, Baltimore & Annapolis Electric Railway, a line built as a direct competitor of the Pennsylvania and the Baltimore & Ohio Railroads, for business between the cities named. The steam railroad fare between Baltimore and Washington is $1.00 for a single trip, with no excursion trip reductions except on Saturdays and Sundays, when a round trip excursion ticket is sold for $1.25. The running time from terminal to terminal is about an hour, but there are a few trains making the trip more quickly; there is a total of 123 trains daily. The electric railway proposes to charge 75 cents per single trip and $1.25 for the round trip, the return coupon being good at any time. This fare includes a transfer on the street railway line in Washington. The running time between Baltimore and Washington is one hour; including the time required on the street cars in Washington, it will take about 75 min. to make the trip between the business center of Baltimore and the Treasury Building in Washington. On the steam road the present fare between Annapolis and either Baltimore or Washington is $1.20 one way and $2.00 for the round trip. The electric line will charge 75 cents for a single trip and $1.25 for a round trip between Annapolis and Washington; the fare between Baltimore and Annapolis has not yet been fixed. The electric line has been designed for the operation of through cars on 15-min. intervals and local cars every second hour, sidings being provided so that the local cars can be passed by the through cars in order to maintain this schedule.



View on Main Line, Washington, Baltimore & Annapolis Railway.

The system has three divisions. The first is a double-track road from Baltimore to the District of Columbia line, the second is a single-track road running from Annapolis to Annapolis Junction on the Baltimore & Ohio R.R. This division crosses the main electric line from Baltimore to Washington at a station known as Naval Academy Junction, which is about 15½ miles from the Baltimore terminus. This branch is practically at right angles to the main line. The third division is a single-track line running north from Berwyn to Laurel. At Berwyn the line connects with the Washington Railway & Electric Co. line, while from the present Laurel terminus it is proposed to build an extension to Annapolis Junction, giving in this way a second entrance into Washington. The total length of the system is 96.3 miles of single track. The line from Annapolis to Annapolis Junction is the old Annapolis, Washington & Baltimore R. R., built about 1885, and recently bought and equipped electrically by the Washington, Baltimore & Annapolis Co.

The technical interest in the new road is twofold, for the electrification has been carried out on the single-phase system, and the connections of the road at Baltimore and Annapolis introduced special problems relating to the operation of the through cars over the street railway systems in the two cities. In Baltimore the gauge of the street railway system is 5 ft. 4½ in., while in Washington it is 4 ft. 8½ in. Standard gauge has been used on the interurban line, and consequently it has been necessary in Baltimore to add a third rail to each track used jointly by the city cars and those of the Washington, Baltimore & Annapolis Ry. At the District of Columbia line the cars will run over the Columbia line of the Washington Railway & Electric Co. to the corporate limit of the city of Washington, where there will be a transfer station at which passengers will change to the cars of the Washington Railway & Electric Co. The double overhead trolley is used in the suburbs of Washington and consequently the cars of the interurban line had to be equipped for it. These operating conditions, at the terminals, the location on the line of the Bennings race track, which makes it necessary to provide for large temporary overload of traffic on parts of the line, and other conditions that need not be enumerated here, finally led the company to adopt the single-phase system.

The general appearance of the main line track is shown in the accompanying illustration. The road is ballasted with gravel from pits along the right-of-way and is laid with 80-lb. Am. Soc. C. E. 33-ft. rails on 6 x 8-in. x 8-ft. chestnut ties. The maximum grade is 5.7 per cent. and is about 500 ft. long; it is an incline in Baltimore up which the cars must go in order to reach the elevated track over which they leave that city. Elsewhere the maximum grade is 2 per cent. The maximum curve is 8 deg., but there is only one curve of this amount, the majority of the curves being 1 deg. or less. On the main line 79 per cent. of the distance is tangent. The elevated line in Baltimore is about 1½ miles long, and consists of about ½ mile of viaducts separated by embankments. This elevation of the tracks was necessary in order to cross over various railroad lines and a number of city streets. There are no grade crossings of steam railways on the entire main line, and but two public road crossings at grade. All overhead crossings are reinforced concrete bridges with solid floors. There are two short tunnels on the line.

The power transmission system is of an unusual nature. Current at 6.600 volts, three-phase is purchased from the Potomac Power Co., of Washington, and converted into two-phase by means of seven 800-kw. T-connected transformers. The electro-motive force of one phase is 6,600 volts and that of the other is 33,000 volts. The former is connected to the trolley system from Washington to Naval Academy Junction, while the latter is connected to a single-phase 33,000-volt transmission line running directly to a sub-station at Naval Academy Junction. At this sub-station there are four 800-kw. transformers which reduce the electro-motive force to 6,600 volts, at which voltage the current is supplied to the interurban sections to Baltimore and Annapolis. In the sub-station there are also two 670-h.-p. 6,600-volt two-phase synchronous motors driving two 300-kw. commutating-pole direct-current generators, compound-wound for 550 to 600 volts. When one of these motors is operated two-phase, one phase receives energy from the track circuits from Washington, while the other receives energy by the more direct way of the 33,000-volt transmission circuit. There is manifestly a considerably lack of balance in the load on the two circuits at all times, and the synchronous motor possesses the advantageous feature of supplying the flexible coupling between the two phases, so that it tends to maintain the electro-motive force on the overloaded phase, to equalize the loads on the two circuits and to improve the power-factor when the excitation is properly adjusted. The motors were not installed to perform these duties, however, for their chief function is to drive the direct-current generators that supply energy at low voltage to the cars throughout the shop yard at Naval Academy Junction and to stationary motors used in the repair shops. Energy will be transmitted from the sub-station to Baltimore and Annapolis over the 6,600-volt trolley-and-rail circuits, single-phase self-starting synchronous motors being used to drive direct-current generators in the sub-stations at Annapolis and Baltimore.

The overhead construction is shown in the accompanying illustration. The trolley line is of the single-catenary type. Although the poles are placed in pairs along the main line, the side-bracket arrangement of suspending the trolley line is used everywhere. The pairs of poles are held together at the top by a wire rope with a wooden insulator at the center, which has been inserted to insure safety to the linemen when they are working on the wire over one track, while the other is in use. The poles are drawn apart by guy wires. The poles are spaced 150 ft. apart on tangents, and the hangers which support the trolley wire from the messenger cable are placed 16⅔ ft. apart, so that there are nine hangers between adjacent poles. On the main line the trolley wire is 19½ ft. above the head of the rail, but on the Annapolis, Washington & Baltimore branch this height is 21 ft. on account of the freight traffic over that line. For the purpose of protecting the trolley wire from static disturbances due to lightning a galvanized wire is supported along the tops of each pole line and connected to earth at convenient intervals. The company also maintains a telephone circuit on cross arms on the side poles. There is no direct metallic connection between the telephone instruments and the telephone line, and other precautions have been taken so that a person using the telephone will not be injured in case the telephone wire should come in contact with the trolley wire or a low-resistance path should be formed between the two.

The Annapolis single-track branch is equipped with Blake manually operated block signals. The tracks at Naval Academy Junction are protected by a block signal system and tower equipped with the apparatus of the General Railway Signal Co. The railway company has not yet selected the block signal system for use on its main line.

Most of the cars are 62 ft. 3 in. long, with Baldwin trucks, and are designed for high-speed service. Each has a main compartment with seats for fifty passengers and a smoking compartment with seats for sixteen passengers. The cars for the local service are 55 ft. long and have a main compartment, smoking compartment and baggage compartment. All cars have M. C. B. couplers and automatic air brakes. The reason for this is that there is a heavy traffic to the Bennings race track, which will make it necessary to use the motor cars in hauling standard railway coaches owned by the Annapolis, Washington & Baltimore line or possibly by connecting steam roads.

There are four trolley poles on each car and it is considered probable that a pantograph may be added later for use on the single-phase section. At the present time no difficulty has been experienced at high speed with the wheel trolleys. One of the trolleys at each end has been insulated for high voltage and its pole is 15 ft. long. The low-voltage trolley pole is only 12 ft. in length and its base is set 38 in. from that of the other. The high-tension pole is used as the positive pole on the double-trolley section of the line in Annapolis. In the District of Columbia the polarity of the two overhead wires is occasionally changed so that the high-tension trolley pole may be either the positive or negative pole of the car.

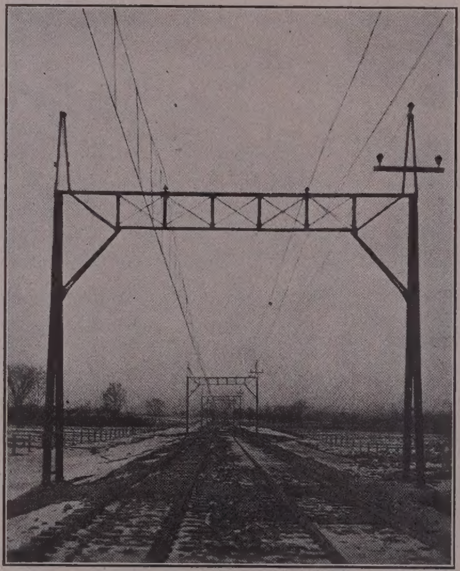
The high-speed cars are equipped with four General Electric A603, 125-h.-p. motors. Where the cars are run on direct current, the four motors are connected in series and subjected to plain rheostatic control. On the alternating-current portion of the line, during the actual starting period, the motors are connected as plain repulsion motors, but are gradually converted to compensated-series motors as the speed increases. There are six points on the controller, each of which is an efficient running point for a certain speed. Each pair of motors receives current from its own oil-insulated self-cooling auto-transformers.

The Washington, Baltimore & Annapolis Electric Ry. Co. has a capital stock of $4,000,000, and is owned in Cleveland mainly. Its officers are Geo. T. Bishop, president; John Sherwin, first vice-president; J. N. Shannahan, second vice-president and general manager; C. F. Gladfelter, treasurer, and W. A. Kappler, secretary. The engineers in charge of the design and construction of the line have been the Roberts & Abbott Co., of Cleveland. Most of the grading, track laying and line work was done by the Fidelity Construction Co., of New York. The electric equipment was furnished by the General Electric Co.

Grand Trunk Pacific Ry. section from Edmonton to Wolf Creek, in the Province of Alberta, Canada, for which contract was recently let, is the most expensive part of the main line yet under contract. This 126-mile division is far the greater part through scrub and marsh approaching the foothills of the Rocky Mountains and was contracted for at $5,000,000.

Bridges for Trolley Wires.

A new type of overhead line construction has been designed and installed under the direction of Mr. Thomas E. Mather, M. Am. Soc. C. E., chief engineer of the Syracuse, Lake Shore & Northern R. R., by the Archbold-Brady Co., of Syracuse. Mr. Mather has recently relocated about 5 miles of the line between Syracuse and Baldwinsville, which will eventually form part of a new high-speed route between Syracuse, Fulton and Oswego, a total distance of about 35 miles. As shown in the accompanying illustration the trolley wire is hung from a messenger cable supported on bridges 300 ft. apart. Each bridge consists of a light truss on bents 30 ft. apart, each bent consisting of two 8-in. channels 6 ft. apart at the base and 8 in. at the top, supported on concrete pedestals 20 in. square. The trusses have 8-in. channel top chords and 6-in. channel bottom chords set flanges down, the diagonal members being ⅝-in. rods and the struts 2½ x 2½ x ¼-in. angles. The struts are flattened and bent over at the ends and riveted to the channels.



New Overhead Construction.

Malleable iron pins are bolted to the top chord of the truss to support the insulators for the messenger cable. The three-phase high-tension line is supported on steel A-frames at each end of the bridge. The construction is designed for a wind pressure of 8 lb. per square foot on the trolley and messenger cables when they are covered with ½ in. of ice, a somewhat lower ice load being assumed on the high-tension cables. The stresses in the bridge have been computed on the assumption that it is a braced portal, and the unit strains under the assumed wind and ice load are 23,500 lb. per square inch, reduced for compression members.

The catenary is strung for a net sag of 6½ ft. at 100° Fahr. At 20° the sag is about 5½ ft., and the trolley is about 12 in. higher at the center of the sag than under the bridges, the height from the rail to the trolley line being 18 ft. The messenger cable is a stranded steel rope 7/16 in. in diameter, with ⅝-in. steel hangers 10 ft. apart. The high-tension line is strung at a sag of 40 in. at 20° Fahr., and has a net clearance of about 24 ft. above the track. As regards the lateral stiffness of this system of suspension, it may be mentioned that during the few weeks the line has been in operation very little deflection or rolling has been observed under the action of the wheel trolley with a tension of about 25 lb. During this time there have been temperature changes of 50° and winds up to 45 miles per hour, without making any appreciable change in operating conditions.

The Prison Ship Martyrs' Monument, Brooklyn, N. Y.

A large and beautiful monument is now being erected in Fort Green Park, Brooklyn, N. Y., in memory of the American soldiers and sailors who perished during the Revolutionary War on the British prison ships in New York harbor. The monument and its surroundings, according to the late Stanford White, one of the firm of designing architects, presents one of the most dramatic combinations known in architecture—a lofty tower on a hill approached by a long series of alternate stairs and terraces.

The monument consists of a tapering fluted column, about 120 ft. high, founded on a monolithic mass of concrete and capped by an ornamental metal lantern, 18 ft. 8 in. high, of the form shown in an accompanying illustration. The column is hollow, the inside diameter being 9 ft. It is built with a lining of common hard brick faced with "Newport white" granite, placed in general in 4-ft. courses. Access is had to the lantern and to the promenade about the top of the column by two spiral stairs, one for ascent and the other for descent, and by an electrically-operated elevator which runs to the top of the column shaft.

The lantern supports a large urn in which will be installed eight 100-candle-power high-efficiency incandescent lamps, each provided with a silvered parabolic glass reflector, the combined effect of the lamps being to throw a vertical search-light beam which will be particularly beautiful on misty nights. A 1-in. gas pipe leads up through the shaft of the monument to a torch above the urn so that for special occasions the monument can be further illuminated by a gas flare at its top. An electric gas lighting outfit is provided for lighting the torch from the floor of the monument.

About the monument the top of the hill has been graded to a nearly level surface to form a plaza about 225 ft. square. At each corner of this area will be erected a granite lamp standard, consisting of a base, pedestal and fluted shaft, all of "Newport white" granite. These standards are about 8½ ft. high and are hollow throughout their upper part, where space is provided in each for an arc lamp of the enclosed type. Each lamp standard has in its side facing the monument a rectangular aperture behind which the lamp hangs. Special reflectors are provided for these lamps so that their light will be thrown on the monument, illuminating it from top to bottom.

The elevator will have a maximum capacity of 2000 lb., and an average lifting capacity of 1600 lb. at a rate of 200 ft. per minute. It will be operated by a direct-current motor placed with the winding machinery in the cellar in the foundation under the column. The car will be cylindrical with a diameter of about 4 ft.

The approach to the monument is, as has been suggested, by way of alternate flights of stairs and terraces, there being three of the former and two of the latter. The horizontal length of the approach measured from the lowest step, which is contiguous to a large open area near the intersection of Myrtle Ave. and St. Edwards St., to the highest step, which is contiguous to one side of the upper plaza before mentioned, is 348 ft. In this distance there is a total rise of 48 ft. The approach has a uniform width of 100 ft. A masonry crypt, placed under the middle flight of stairs of the approach, will receive the few existing remains of those to whom the monument is erected. The steps are of "Maine pink" granite and the terraces are paved with a granolithic finish; the other stone work is "Newport white" granite like the monument.

The erection of the part of the monument above the foundation was begun about Oct. 20, 1907, and by Jan. 28 it had reached a height about 100 ft. above the level of the plaza. The facing stones in the shaft weigh in general about 2¼ tons each and some of the stones in the capital weigh as much as 7½ tons. To handle these and to deliver brick and mortar to the masons, a four-legged timber tower, high enough to command the work from start to finish was erected within a few feet of the foundation and on the top of this is mounted a stiff-leg derrick with a 32-ft. boom and a 28-ft. mast. Its legs are made up of 12 x 12-in. timbers in 24-ft. lengths, joined at each splice with four 3 x 12-in. fish plates. These legs are erected on the corners of a 28-ft. square and extend upward without batter to a height of 120 ft. where they support a plank platform above which is the derrick. The tower is divided into five nearly equal vertical bents by rings of horizontal bracing timbers, each member on each side of the tower being made up of two 4 x 10-in. planks, the two planks in each case being separated by the width of the legs, which are bolted between them. On all sides of the tower each panel thus formed is X-braced in each direction with two 4 x 10-in. planks.

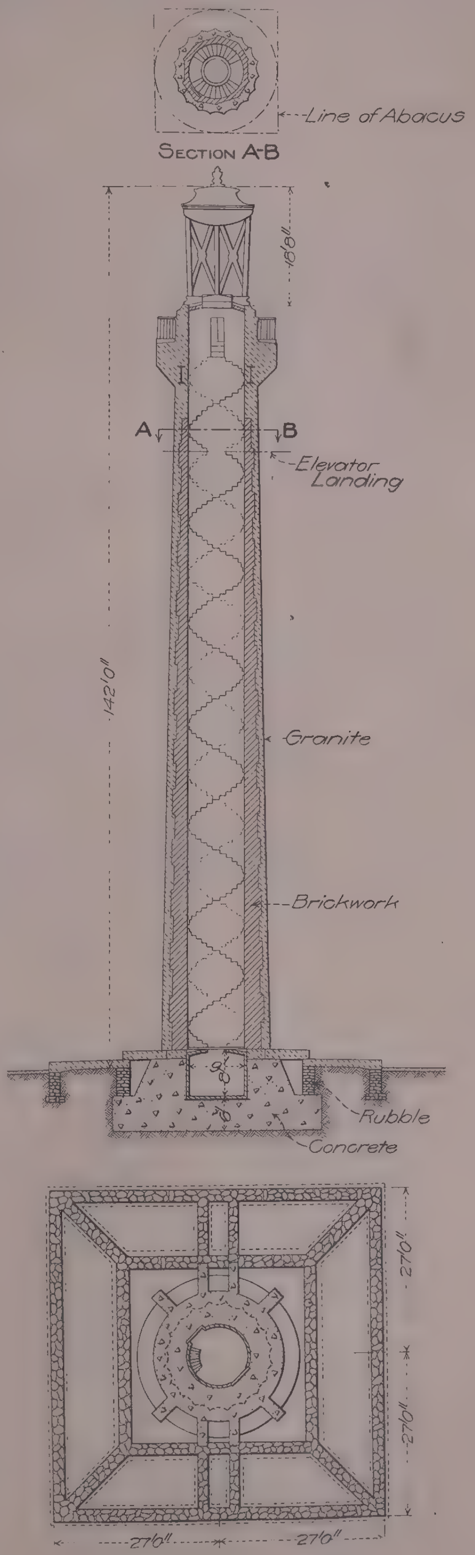
When the derrick tower was designed it was planned to make it available for general contracting purposes by building it to handle heavier loads than are to be handled on the work described. It can also be readily and safely extended to a height greater than 120 ft. if this is desirable on future work. The erection and dismantling of the tower has been facilitated by using bolted connections throughout; to insure a perfect fit one leg was laid out and spliced on the ground and the other leg timbers and fish plates were bored, using the parts of the first leg as patterns. The tower was erected in 24-ft. lengths, corresponding to the length of the leg timbers, by a 45-ft. gin pole, which was raised successively as the tower was erected to the top of each 24-ft. section, where it was stepped on the end of a series of 6 x 6-in. timbers placed end on end in the center of the tower and braced securely at each bent to provide lateral support. The gin pole was guyed out with wire cables which, when the erection was completed, were transferred to the legs of the tower at the top to serve as guys for it. When the work is finished the tower will be dismantled by the same gin-pole method.

The derrick is operated by a Lidgerwood double-drum engine and boiler placed near the tower, the cables being carried through a 2-wheel pulley attached to the tower leg under the derrick mast and thence directly to the derrick. The boom is swung by hand lines run through pulleys attached at suitable points to the framework of the tower.

The brick masons work on a circular platform just large enough to clear the inside of the finished shaft. This is supported on two bearing timbers let into chases or put-locks left in the brick lining about every 4 or 5 ft. The platform is hoisted to its successive positions by the tower derrick. The force engaged on the work is in general made up of three stone-setters, three bricklayers and eight laborers. The maximum vertical progress accomplished in a single day and in a single week was 4 ft. and 12 ft., respectively. The mortar used is a 1:3 mixture of Atlas Portland cement and Cow Bay and white beach sand.

The degree of care required in cutting and setting the granite courses of the shaft is very great because of the accuracy with which the lines of the flutes must be maintained. The slightest variation from a straight line other than that required by the entasis of the column would be very noticeable because of the shadow upon the concave surfaces between any two arrises. In order, therefore, to preserve the exact lines, a transit was used to prolong diameter lines through the center and through each arris at the intersection of flutes. By setting up on some point on this line, the observer is in the plane of the arris and can direct the settings, thus preventing any winding. In the same manner tangent observations control the departure from the vertical.

The cost of the tower, which is estimated at $200,000, is to be borne one-half by the United States Government, one-fourth by the State of New York, one-eighth by the City of New York and one-eighth by popular subscription among societies and individuals prominent among whom is the Prison Ship Martyrs' Monument Association of New York. The monument was designed in competition by Messrs. McKim, Mead & White, New York, and is being built by the P. J. Carlin Construction Co., New York, under the joint supervision of Mr. G. L. Kuehule, representing the War Department, and Mr. A. L. Harmon, of the firm of Messrs. McKim, Mead and White.



Prison Ship Martyrs' Monument.

The Runoff from Sewered Areas.

Some months ago attention was called in this journal to an investigation of the relation between rainfall and runoff on sewered areas which had been undertaken by a committee of the Sanitary Section of the Boston Society of Civil Engineers, consisting of Messrs. Irving T. Farnham, George A. Carpenter, Hector J. Hughes, Harrison P. Eddy, L. M. Hastings, Arthur T. Safford and W. S. Johnson. In a preliminary report issued recently the committee reports that it has succeeded in establishing a few stations for observations of rainfall and runoff, has studied the information thus obtained and formulated the following suggestions as to methods of procedure which may be of service to those interested in similar work. For the purposes of this investigation, the committee is of the opinion that the apparatus mentioned below, if properly installed and cared for, will give satisfactory results.

Apparatus.—Automatic recording rain gauge. This should be located as near the center of the drainage area as practicable, at a point free from obstructions, such as buildings, trees, etc., preferably on level ground. On large areas the value of the results will be increased if more than one rain gauge is installed.

Standard rain gauges. These should be so placed as to show the variation of the precipitation over the watershed under consideration. One gauge should occasionally be used for the purpose of checking the automatic rain gauge.

Automatic run-off gauge. This should be installed preferably in a side chamber connected by a pipe, with the drain to be observed, but where this is not practicable it may be installed in the drain itself, the float being protected by a surrounding chamber so arranged as to counteract the impact of the water. The clockwork and recording device may be installed in a manhole, but will give much better results if placed in a box above ground, so constructed as to exclude most of the moisture coming from the drain. Such boxes, like police boxes, have in some cases been placed on posts located either on the curb line of the street or on private property.

Maximum run-off gauges. At least three of these gauges should be provided, one placed as near the automatic run-off gauge as practicable, another below and the third above the automatic gauge on the same line of drain, these gauges to be used to check the automatic gauge and to determine the slope of the water surface.

If ten stations are established calling for new apparatus, the following club prices may be obtained: One recording rain gauge, $100; two standard rain gauges at $10, $20; one run-off gauge, $45; three maximum run-off gauges, $3; total, $168.

Records.—There has also been considered the matter of a standard form of chart to be furnished by the committee, upon which the results obtained at the various stations are to be recorded, and sent in. A tentative form for the same has been prepared, and copies may be obtained upon application to the secretary of the committee, Mr. H. P. Eddy, 14 Beacon St., Boston.

The committee deems it necessary that each observer should furnish, in addition to the charts, the data suggested in the following schedule:

1. Drainage area. Map of drainage area, preferably to a scale of 100 ft. to 1 in. or multiples thereof, with elevation at street intersections noted, and tributary area computed. Show all drains with sizes, invert elevations at manholes and rates of slope, catch basins and overflows. All ponds, brooks and other natural or artificial channels. Different areas making up watershed colored as follows: Swamp, dark green, areas computed; wooded, light green with trees, areas computed; meadow, light green with edges of

high land brought out, areas computed; streets, whether gravel, macadamized or paved and form of paving used, areas computed; state number of houses and other buildings with connections, and indicate manufacturing establishments, if any.

2. Rain gauge. Sketch showing location of rain gauge with surrounding objects, approximate elevation above ground and distance from nearest trees, buildings, etc., on scale 10 ft. = 1 in. Type of automatic recording gauges used. Sample dial or sheet.

3. Measuring station. Plan and elevation of run-off measuring station, connection with recording gauge, etc., on scale of 10 = 1 in. or larger. Type of automatic recording float gauge used. Sample dial or sheet.

The committee will be pleased to receive any suggestions or advice, and it is particularly desirous of co-operation on the part of those interested by the establishing of as many gauging stations as possible. The committee will be glad to furnish, so far as lies within its power, any further information or suggestions concerning the scope of the work or the apparatus required. It is intended that proper credit shall be given to those furnishing data, for their respective contributions. The committee expects to keep in close touch with those making observations, and give to each the benefit of the experience of other observers, and also the results obtained as soon as practicable.

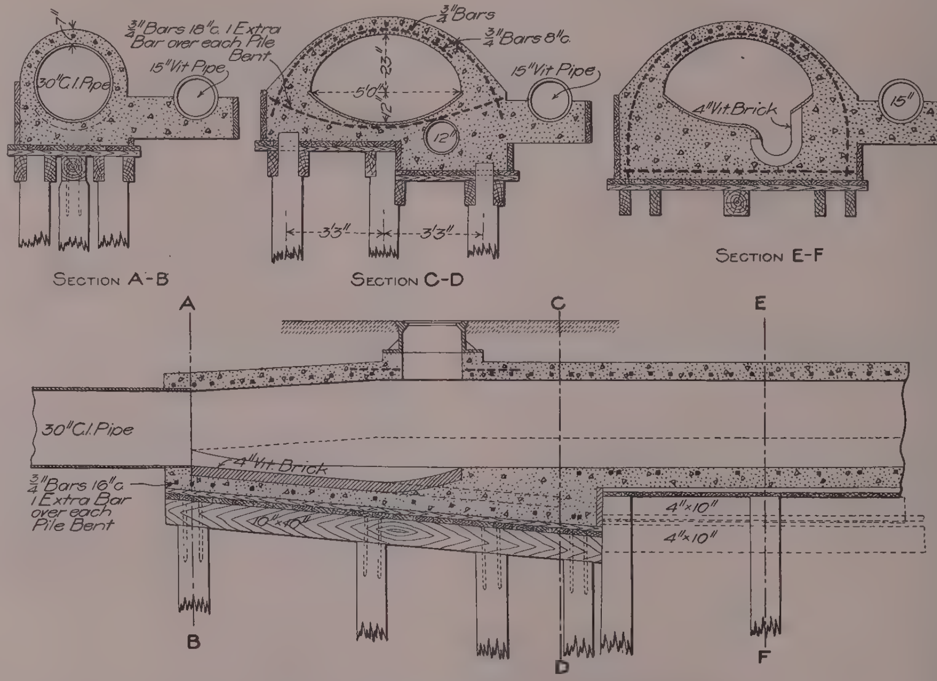
A Cast-Iron Pressure Sewer in a Railroad Yard.

At Tompkinsville, Staten Island, N. Y., the Baltimore & Ohio R.R. maintains an extensive terminal yard in which large quantities of heavy freight, including coal and building stone, are handled. As many as 900 loaded cars often are in the yard at one time. The yard is just north of the terminal of the municipal ferry to New York City, and is contiguous on its east side to the water front, where piers and slips are provided and where the heavy freight is loaded from vessels into cars. On its west side the yard is contiguous to Jay St., the level of which is in general about 20 ft. above the average level of the yard. The general elevation of the latter is about +7, datum being mean high water. West of Jay St. the surface of the ground rises on a steep slope running back a considerable distance. This sidehill is a resident section.

Up to the present time no means has been provided to carry the surface run-off from this side hill across the railroad yard and during heavy rains the latter has often been flooded, seriously handicapping its efficient operation. Now, however, in connection with the extensive improvements of the sewerage of the island, some features of which were described in The Engineering Record of Nov. 4, 1907, a sewer designed to operate under pressure is being built across the yard from the bulkhead line to a drop manhole near Jay St. The storm water run-off and house sewage flow from a 47-acre sidehill area, known as Sewerage District No. 8 A, will be led to this manhole. At present this district is not closely built up, but the sewer has been designed to serve the district under the thickly settled conditions which it is expected will obtain in the future. Under these conditions the drop manhole may at times be filled full and the maximum head on the sewer will then be about 13 ft.

For a distance of about 535 ft. east of the manhole the sewer is made up of 12-ft. lengths of 30-in. cast-iron pipe laid on a grade of 0.280 per cent. and supported most of the way on piles, two piles to the bent, the bents being 6 ft. center to center. In this distance the pipe is crossed by 24 switch tracks and two main passenger tracks; the cover varies from 2 to 3 ft. About 70 ft. from the bulkhead line the cast-iron pipe runs into a concrete transformer about 6 ft. long, which in turn connects with a storm water overflow chamber 65 ft. long, designed to reduce the velocity of flow and prevent erosion as the storm water spills out at the bulkhead. This overflow chamber is in effect a short section of reinforced concrete sewer with a flat-curve invert and a low arched roof, with the form and dimensions shown in an accompanying illustration. The elevation of the invert of the chamber at the bulkhead line is 0.699.

The sewer carries both storm water and house sewage, as has been indicated, and the latter must not be discharged within the pier-head line except in times of flood flow when it would be so diluted with storm water that the discharge at the bulkhead would be in no way objectionable. To carry the dry-weather flow the required distance beyond the bulkhead line, 10 to 20-in. cast-iron pipe, supported on piles, has generally been used in connection with the outlet sewers constructed during the past year or two, as described in The Engineering Record of Nov. 2, 1907. This saves the expense of carrying the main sewer out into the water a distance of several hundred feet. In the case of the work described, 455 ft. of 12-in. cast-iron pipe were used, laid on a 0.644 per cent. grade, and as the main outlet from the expansion chamber comes just at the shore end of a 455-ft. pier, the cast-iron pipe is supported by hangers attached to the floor beams of the pier instead of on piles in the usual manner. The manner in which the dry-weather flow is collected in a depressed channel in the overflow chamber and led into the cast-iron pipe is clearly shown in accompanying illustrations.



Sections of Transformer and Overflow Chamber.

Supported on the same foundation as the main sewer, parallel to and at one side of it, is a vitrified pipe drain 15 in. in maximum diameter and decreasing to 12 in. in the western part of the yard. This is designed to carry the surface water collected in the yard, catch-basins being provided at intervals with inlets into the drain.

The presence of the railroad tracks and the fact that cars are standing on most of them the greater part of the time makes the construction of the sewer particularly difficult. The piles vary from 12 to 36 ft. in length. They were driven to a solid bearing in firm material underlying the soft filled-in material on which the tracks rest with a 2400-lb. drop hammer which was moved along with rollers on skids in the usual manner, the operation of the yard being modified somewhat to allow the work to proceed as rapidly as possible. Through the part of the yard where the tracks are close together the pipe will be laid by taking up every fifth track and opening up a short piece of trench and then tunneling under the remaining tracks between the trench openings. The pipes, which weigh about 4,400 lb. each, will be delivered into the trench with a portable derrick and pulled into place with a tackle.

The concrete overflow chamber is crossed diagonally by a track leading out onto the pier before mentioned. Large quantities of Indiana limestone are unloaded on this pier and the track in question carries some of the heaviest traffic in the yard. The reinforcement of the sewer arch is accordingly very heavy, as shown on the drawings. Both corrugated and twisted bars were used.

The concrete is a 1:2:5 mixture of Phœnix Portland cement, sand and crushed trap rock. It was mixed in a Eureka continuous mixer made by the Eureka Machine Co., Lansing, Mich. The invert had to be placed during periods of low tide, but the work was successfully and rapidly accomplished, about two days being required for the laying of the invert.

The engineering work for construction in the Borough of Richmond (Staten Island) is under the general direction of Mr. Louis L. Tribus, consulting engineer and Commissioner of Public Works, and Mr. Theodor S. Oxholm, engineer in charge. Mr. L. W. Freeman, assistant engineer, has direct supervision of sewer work. The designs for the sewer were prepared by Mr. V. H. Reichelt, assistant engineer. Messrs. Joseph Johnson's Sons are the contractors for the work.

European Laborers have been imported for work on the Panama Canal to the number of 9,915, and at the close of 1907 there were 4,793 still on the pay-roll. The others had either returned to their native countries or gone to South American railway construction camps. Those remaining are the best of the lot and about twice as efficient as the West Indian laborers. The common laborers among them are paid 40 cents silver an hour, without subsistence. The West Indian common laborers are paid 13⅛ cents silver an hour, with subsistence. The West Indians of the artisan class are paid 36 cents and 32 cents an hour.

THE ESTIMATED COST OF THE MAIN ASHOKAN DAMS.

A Statement of the Methods Followed by the Engineers of the Board of Water Supply.

It has been announced that Mayor McClellan has, on the advice of Corporation Counsel Pendleton, dropped the matter of preferring charges against the members of the Board of Water Supply, on the ground that the evidence obtained during the course of the public hearings concerning their administration held by the Commissioners of Accounts was insufficient. In view of the widespread interest manifest among engineers in the outcome of this case, which had for its grounds of complaint the award by the Board of Water Supply of the contract for the main dams of the Ashokan reservoir to the next to the lowest bidder at an advance of over $2,300,000 above the low bid, a brief review of the history of the case will be of interest to all of those who have to do with municipal work.

History of Case.—The Board of Water Supply, acting under the authority of Chapter 724 of the laws of 1905, made plans for the construction of the Ashokan reservoir, and on July 1, 1907, the final form of contract for the construction of the main dams of this reservoir was approved by the Corporation Counsel and its advertisement ordered and published. On Aug. 6, 1907, five bids were received as follows: John Peirce Co., $10,315,350; MacArthur Bros. Co. and Winston & Co., $12,669,775; Bradley Contracting Co., $13,931,250; Stewart, Kerbaugh, Shanley Co., $13,979,813; O'Rourke Engineering Construction Co., $14,707,750. The Chief Engineer's estimate for the cost of this contract was $12,850,000.

With each of these bids there was filed a certified check of $250,000 as a guarantee that the contract would be entered into, if awarded, and bonds in the sum of $1,000,000 given, guaranteeing the prompt and faithful execution of the work. As usual the certified checks were to be returned to all of the bidders when the contract was duly executed.

The Board of Water Supply referred the bids to its chief engineer for investigation, and, on Aug. 20, he reported in unqualified terms that the best interests of the city demanded that the contract be awarded to the second bidder. Each of the three consulting engineers, Messrs. Freeman, Burr and Stearns, also, in separate reports, advised that the contract should not be awarded to the low bidder. The Board of Water Supply then considered these reports in the light of their experience as successful business men and, on Aug. 26, awarded the contract to MacArthur Bros. Co. and Winston & Company.

Certain of the daily papers thereupon began a campaign alleging that the members of the Board of Water Supply and their engineers were incompetent, that the fact of the award was proof of this incompetency, and that their action was contrary to public policy in that it constituted an extravagant waste of public money.

Mayor McClellan, moved by these allegations, and in spite of the opinion of the Corporation Counsel dated Oct. 3, 1907, that the contract had been legally awarded, and that unless fraud could be proved it must be legal and binding on the city, ordered his Commissioners of Accounts, Messrs. John Purroy Mitchell and Philip B. Gaynor, to conduct an investigation into the action of the Board of Water Supply with a view to ascertaining whether these charges were well brought. The Commissioners of Accounts appointed, in order to obtain technical advice, a board of experts consisting of Major Thomas W. Symons, Mr. Halbert Powers Gillette, Mr. Daniel J. Hauer, and Mr. Otto H. Klein. This Board, appointed on Oct. 29, visited the site of the work on Oct. 30 and 31, and on Nov. 6 reported that the action of the Board of Water Supply in awarding the contract to MacArthur Bros. Co. and Winston & Co. was without justification; that the work could be done at a profit at the figure named by the lowest bidder, and that the principle of accepting on public works any bid other than the lowest was by no means to be approved of in the case under consideration. This report, while serving as the bill of complaint on which the Commissioners of Accounts acted, was not then, nor has it yet, been made public. Its conclusions only were incorporated in the report of the Commissioners of Accounts to the Mayor dated Nov. 8, in which they recommended that "In view of the clean-cut issues which are raised by this report of our Advisory Board of Engineers, and of the great importance of the undertaking which is the subject matter of this contract, and of the deep public interest which has been manifested in the award of this contract to a bidder, other than the lowest, we propose with the approval of your Honor to hold public hearings in this matter, at which we will examine under oath all persons who may be able to throw light upon this question and establish or disprove the contentions of the Engineers of the Board of Water Supply upon which that Board based its action. To this end, we propose to request the co-operation and assistance of the members of the Board of Water Supply."

Sessions of this public hearing were held on Nov. 18 and almost daily thereafter until Dec. 6, when adjournment was had. During the course of this hearing 1615 pages of testimony were taken, and then on Dec. 25 the Commissioners of Accounts reported to the Mayor that the members of the Board of Water Supply had not taken proper measures for informing themselves as to the merits of the low bid; that in general they had not displayed the attention to detail which public duty demands, and that their action in ignoring the bid of the John Peirce Co. would result in an extravagant waste of public money. In this report they stated that charges looking toward the removal from office of the members of the Board were in course of preparation and would soon be presented to the Mayor for action by him.

After a lapse of several weeks these charges were not forthcoming and the Mayor thereupon took the whole matter from before the Commissioners of Accounts and put it into the hands of the Corporation Counsel, who called to advise him the following engineers: Major Cassius E. Gillette, Mr. Arthur P. Davis, Mr. R. W. Creuzbaur, Mr. Edward Wegmann, Mr. Otto H. Klein, and Mr. Chauncey Ives.

Finally, on Jan. 20, 1908, Corporation Counsel Pendleton rendered an opinion that the evidence obtained at the public hearings and otherwise was insufficient for the purpose of basing on it the charges necessary for the removal of the members of the Board of Water Supply.

The Chief Engineer's Estimate.—The estimate of the chief engineer, Mr. J. Waldo Smith, of the cost of the work under this contract was personally made by him. Broadly speaking, it was based on his past experience on works of similar nature and on his knowledge of the conditions under which work for the city must be done.

Specifically, his estimate was based on a knowledge of the actual cost of similar work done during his connection with the East Jersey Water Co. on the Clinton and Oak Ridge dams for the water supply of the City of Newark. The work on these two dams was done by "force account" and the actual costs were therefore known to him. The dam for the Great Notch reservoir was also built by this company and while not directly connected with the work, he knew what the costs were. The Boonton, N. J., dam and the Little Falls, N. J., filtration plant were constructed under his direction and careful labor costs were kept on them from beginning to end. The construction of the New Croton dam and the Muscoot dam were under his direction as chief engineer of the Aqueduct Commission (1903-1905) and the Cross River dam was under contract before his resignation from that office. On these works also, labor costs were kept and the expense of this part of the work was known to him. Moreover, he had a knowledge, as all engineers have, of the cost of work, gained from the engineering press, from visits to work under construction, and from conversation with engineers.

The chief engineer had an exact knowledge of the physical conditions under which the work must be done and of the nature of the materials which will be encountered. This knowledge was gained by many visits to the ground, from personal inspections of the borings and test pits, from the reports of the geological experts, from conferences with his consulting, department, division and designing engineers and from their weekly and special reports. The investigations and studies, extending over a period of nearly two years and having for their ultimate end the preparation of plans and specifications for this work, were at all times under his supervision. Without these investigations and studies and without the knowledge derived therefrom, no plans and specifications could have been drawn and most certainly no estimate could have been made. The studies preliminary to the final location of the main dams involved studies of alternative locations which were weighed from all points of view, including that of cost. Estimates of the cost of these alternative locations were made many times and submitted to the chief engineer for his decision.

The total of the chief engineer's personal estimate for this work was $12,850,000. On the morning of the day the bids were opened, he was confirmed in this by four other estimates as follows: Carleton E. Davis, department engineer, $13,000,000; T. Merriman, assistant to chief engineer, $12,506,000; C. E. Gregory, designing engineer, $13,019,000; F. F. Moore, designing engineer, $12,748,000.

The five bids previously mentioned, were referred to the chief engineer for examination and report, and, in doing so, he naturally carefully re-examined his own estimate, as did all of those who had estimated on the work. After long and careful study, and after consultation with all of those who had estimated on the work, with Consulting Engineers Freeman, Burr and Stearns, and with the other engineers both in the employ of the Board of Water Supply as well as outside of it, the chief engineer reached the conclusion that a serious error had been made in the bid of the John Peirce Co., and that their bid was below the actual cost of doing the work. This being the case, in view of the imperative need of the city for more water and the necessity for the avoidance of delay, only one course of action was open to him, and he recommended that the second bid be accepted.

Analysis of the Estimate.—In detail, if the estimates of Chief Engineer Smith, Mr. Davis, and Mr. Merriman were combined, it would be found that they were based on the following considerations, as well as on the actual cost prices of similar work which will be given hereafter.

These estimates are combined in this manner only for the sake of brevity, and in order to avoid repetition. These estimates were based on an intimate knowledge of the physical characteristics of the region derived from two years' study, and, in the case of Messrs. Davis and Merriman, nearly two years' residence on the ground. This knowledge of physical conditions was further based on:

(a) Reports on the geology of the region by Prof. Crosby, of the Massachusetts Institute of Technology, by Professor Kemp and by Dr. Berkey, both of Columbia University. These experts agreed that the prevailing type of earth in the Ashokan region is a boulder clay compacted and solidified by the weight of the great ice sheet which laid it down and passed over it.

(b) Temperature and weather records, confirming the supposition that the working season in this region is short, and for embankment will probably be limited to 140 days a year. Snow and freezing weather are usual up to the middle of April, and are to be expected throughout the whole of November. Rainfall records for the last five years show an average of eight rainy days per month (April-November), with probably six days a month, in addition to Sundays and holidays, when no work could be done on embankments.

(c) Borings and test pits fully proving the dense, impervious character of the local earth; its nearly universal distribution; and the large number of stones and boulders contained in it.

(d) Borings for quarries, substantiating the report by Dr. Berkey, that local stone of suitable character could be found in sufficient quantity to build the dams, but that all quarries would develop considerable waste.

(e) Test pits in sand deposits, showing sufficient sand for the needs of the construction, but indicating the necessity of considerable sorting, screening and washing.

(f) Stream gaugings resulting in a knowledge of their behavior in times of freshet.

(g) Study of the action of the local earth when wet, demonstrating its tenacious, sticky and practically unworkable condition, when too moist.

(h) Experiments on the percentage of stone in the local boulder clay, resulting in the belief that from 10 to 20 per cent of the total mass consists of stones too large to be incorporated into rolled earth embankment.

With this knowledge of the local conditions the independent estimates heretofore referred to were made. They were basd on the following costs of work of somewhat similar character and performed under largely similar conditions.

(1.) Cedar Grove Reservoir for Newark, N. J.—Located in Verona, N. J., near Montclair. Contained about 450,000 cu. yd. of rolled embankment 5 in. thick when rolled; core-wall in center of embankment; principal dike, 60 ft. high, ½ mile long; haul, about 3000 to 5000 ft. for round trip; material, similar to that at Ashokan as regards boulders, but did not contain as much cementing material. Plant: steam shovels, Vulcan, Bucyrus, Marion, about 60 to 70 tons, with 2 to 3 cu. yd. dippers. Locomotives and cars, 3-ft. gauge, cars about 4 cu. yd. capacity. Some drilling and shooting necessary to loosen the material in the borrow pits. Ten-ton steam road rollers were used. Spreading was done by hand and by road machines. Watering was done by hose and carts. Some earth moved by scrapers and elevating graders and some by horses and wagons. The tracks on the embankment were thrown by hand, by horse and by traction engines. Work was carried on from Sept., 1901, to Aug., 1905, with 10 hours per working day and the average wage was $1.50 to $1.75.

The cost of this embankment as estimated by C. E. Davis from records of cost kept was 45 cents per cubic yard. This estimate included only the items of expense ordinarily accessible to engineers. On this same job there were also 160,000 cu. yd. of core-wall trench excavation in earth, and some 60,000 cu. yd. of concrete.

(2.) High Hill Reservoir, New Bedford, Mass.—Built in 1896-1897. Required 150,000 cu. yd. rolled earth embankment in 4-in. layers after rolling. There was no core-wall. The reservoir was 1000 x 500 ft. and the embankment was formed with material excavated from interior of the reservoir. Plant: Steam shovel, Marion, 60-ton, loading into wagons. A 10-ton road roller was used and spreading was done by hand. There was also some wheel-scraper and hand work. The material was boulder clay, similar to that at Ashokan, with somewhat fewer stones. The working day was 10 hours and first-class labor was paid $1.15 to $1.25 per day. The material was measured in excavation. The cost as kept by C. E. Davis by careful force account was 35 cents per cubic yard, including all items usually accessible to the engineer.

(3.) Great Quittacas Dam, New Bedford Water Works.—Built in 1897. Required 25,000 cu. yd. earth embankment. There was no core-wall. The embankment was put in in 8-in. layers, wet, but not rolled. The material was gravel with no stones to take out. The excavation was done by hand and loaded into cars which were hauled by a locomotive of 3-ft. gauge. The contract price was 35 cents measured in excavation. There was a fair profit to contractor. No trouble in doing work was experienced on account of the tracks on the embankment (C. E. Davis).

(4.) Various reservoir embankments at Panama, and general steam shovel experience gained from furnishing water for them (C. E. Davis).

(5.) High Service Reservoir, Manchester, N. H.—Small amount of earth embankment (C. E. Davis).

(6.) Cost of steam shovel work on the West Shore Railroad, from records kept by L. F. Searle, assistant engineer B. W. S., and Edw. T. Grandlienard, assistant engineer, B. W. S. The former had been in charge of the work for the railroad, and the latter contractor's engineer. Both assisted in making up estimates for the Reservoir Department. This work was done in 1905-1906 on a 10-hour day basis and consisted of items as follows: Fifteen miles additional track between Utica and Syracuse; two 70-ton steam shovels handling various classes of material were used. Twenty-two grade revisions, requiring about 45 miles of second track, between Syracuse and Rochester; four steam shovels were used on this work. The material varies from sand and gravel to well compacted clay and gravel; the cost was between 25 and 40 cents per cubic yard. The principal piece of work of all these revisions was the Macedon cut of 80,000 yd. hard clay, gravel and sand, and was handled by a 70-ton Bucyrus shovel. The cost to the contractor was 40 cents per cubic yard, measured in excavation. Practically no interference was caused by the operation of the railroad and considerable assistance in the way of track, etc., was furnished by the railroad company.

(7.) The Clinton and Oak Ridge dams constructed by the East Jersey Water Co., in Passaic County, N. J., for the supply of the City of Newark. The work on these dams was done for the company by force account and exact cost therefore known. These costs were available to Mr. Smith and ranged from 55 to 80 cents per cubic yard when reduced to an 8-hour day and the prevailing present rate of wage. The material used in the construction of these dams was similar to that at Ashokan. Horses, carts and wagons were used, the haul being short. Rolling was done by horse rollers. The higher costs were those in material which contained the greatest percentage of stones and the total quantity of embankment was 150,000 cu. yd.

(8.) The Great Notch Reservoir near Paterson, N. J., was also built by the East Jersey Water Co., the construction being done under similar arrangements by force account. The actual cost here was also known to Mr. Smith and was 60 cents per cubic yard. It was put in by scrapers, carts and wagons and rolled by horse rollers.

(9.) The Boonton, N. J., dam, where there were 40,000 cu. yd. of rolled embankment and 260,000 cu. yd. of masonry and on which a careful labor account was kept, furnished Mr. Smith with unusual data in the way of cost. The embankment here was put in in 6-in. layers by scrapers and elevating graders delivering into wagons; it was rolled by both steam and horse rollers and the cost of labor alone reduced to an 8-hour day and Ashokan wage conditions were 38 cents per cubic yard.

(10.) The Parsipanny dike constructed in connection with the Boonton, N. J., reservoir was also under Mr. Smith's direction. The quantity of embankment here was 160,000 cu. yd., which was to be rolled on one side of the core-wall only, in 6-in. layers, the other side being unrolled. The contract price reduced to an 8-hour basis was 48 cents per cubic yard. At this figure the contractor failed and the work was finished by the company. The work was done by elevating graders and wagons, after a steam shovel and cars had been tried and found not satisfactory. The material here was a glacial drift in every way similar in its condition and variety to that which will be found at Ashokan.

(11.) All of these works, together with the new Croton dam, the Muscoot dam, and the Cross River dam, furnished Mr. Smith with data as to the actual cost of work, all of which entered into the preparation of his estimate.

(12.) The records of labor cost on the Boonton dam were kept from beginning to end under the observation of Mr. Merriman, and, latterly, under his direction. His estimate of the Ashokan dam was based largely on these costs and also on his experience on the New Britain, Conn., waterworks, and his observations on the construction of an earthen dam of about 20,000 cu. yd. for the Lehigh Valley R. R. at Delano, Pa. In confirmation of his estimate based on actual cost prices, he followed the so-called method of cost analysis on some of the items of excavation and embankment and arrived at a substantial agreement. He also, when connected with the Reservoir Department, and resident in the Ashokan district, had occasion to study alternative designs and locations for the work under this contract. In connection with those studies he made estimates of cost and of various methods of handling the materials.

(13.) Detailed studies of possible methods of construction, with the object of ascertaining if work could be done by cheaper methods than those followed on other pieces of work from which deductions were drawn.

Mr. L. F. Searle, assistant engineer, B. W. S., experienced in railroad construction and steam shovel work, working under direction of Mr. C. E. Davis, spent nearly all his time for four or five months laying out different methods of operating borrow pits, transporting material from borrow pits to banks, and different systems of handling material on banks. Incidental to this work, progress profiles were made illustrating the possibile distribution of plant, most economical placing of steam shovels, number of steam shovels required, etc.

(14.) Opinions of various engineers of wide experience on the probable cost of the work:

(a) Mr. Francis Lee Stuart, chief engineer of the Erie R. R., who made a study of local material in connection with the relocation of the Ulster & Delaware R. R., and considered that steam shovel excavation and embankment for railroad work in this region would cost 38 cents per cubic yard, with a 10-hour working day.

(b) The same opinion was expressed by Mr. George C. Clarke, resident engineer, Pa., N. Y. & L. I. R. R. Co., who also examined the Ashokan material for the same purpose as did Mr. Stuart.

(c) Mr. Horace Ropes, from his study of the local material in connection with railroad matters and from his experience with rolled earth embankment and knowledge of other local conditions, considered that contractors for Contract 3 should have 60 cents per yard for Class A Embankment.

(15.) A knowledge of the governing local conditions which will affect the carrying out of the work as follows:

(a) Possible conflict with other contractors; notably Contract 10 for Aeration Works.

(b) Interference due to the necessity of maintaining the present Ulster & Delaware R. R. for a number of years.

(c) High freight rates on the Ulster & Delaware R. R. and absolute dependence on that road, without competition.

(16.) The fact that this work was to be done for the City of New York meant also that a number of conditions affecting the cost must be considered. Among them are:

(a) The great length of the contract and the possibility of changes in administration and engineering forces.

(b) The difficulty of modifying a city contract to meet unforeseen difficulties should they arise.

(c) The difficulty of a contractor in getting prompt payments for his estimates from the city and the consequent interest charges he must meet or else see his profits cut into.

(17.) The physical difficulties with which a large piece of embankment work is beset and which cannot be appreciated by anyone who has not had actual experience in this kind of work.

(a) No frozen material can be put into an embankment nor can any material be put onto an embankment which is itself frozen.

(b) No work can be done when either the embankment or the materials being put into it are too wet to admit of rolling.

(c) Every rainy day, therefore, occasions a loss of time greater than the actual time lost while the rain is falling.

(18.) The operation of the 8-hour law. This affects the cost of work by increasing it for the following reasons:

(a) The daily wage paid for an 8-hour day is practically the same as for one of 10 hours. The amount of work done per hour is the same and an 8-hour day sees about 20 per cent less accomplished. The cost, therefore, is correspondingly increased.

(b) Since the daily working time is decreased 20 per cent, the working year is correspondingly shortened. In order, therefore, to accomplish a given amount of work within a certain calendar time, the plant necessary to do the work must be increased by 20 per cent. This means that the interest charges on the plant must be increased. It also means that on a work as large as the one under consideration and extending over a similar period of time that the plant charges are also increased by very nearly 20 per cent, for the reason that any machinery installed at the beginning of the work will have become obsolete before its close.

(c) In spite of the increases in plant necessary to complete a work under an 8-hour regime within the same calendar time as would be required if 10 hours was the rule, the calendar time of doing the work will be lengthened and the possibility of the occurrence of strikes, epidemics, floods and accidents proportionately increased.

(19.) Recent contract prices for similar work under similar conditions. Only one case of many need be mentioned, the Croton Falls dam now under construction for the City of New York in the Croton watershed. The price for earth excavation Class A there, which corresponds very closely to earth excavation Class C at Ashokan, was 75 cents per cubic yard, while the price for the rolled earth embankment in 6-in. layers was 40 cents per cubic yard. In studying these prices, it must be remembered that the quantity of excavation is 490,000 cu. yd., and the quantity of rolled embankment 203,000 cu. yd., and that most of the excavation can readily be used in the embankment. The price for excavation added to that for embankment is $1.15 per cubic yard, whereas the sum for the corresponding items of the John Peirce bid is but 72 cents per cubic yard. The difference between $1.15 and 72 cents represents the difference between success and failure. At the time the Croton Falls work was let, no complaint of excessive cost was raised, yet there is no difference between the prices there and those of the engineers' estimate for the work at Ashokan.

(20.) Published cost data were used in the preparation of these estimates to a limited extent only, for the reason that unless all the conditions which surround a piece of work are known, it is extremely difficult to properly interpret them. Sufficient knowledge of a work in order to enable one to use cost data gathered on it can be gained only by spending much time on the work or else by being directly connected with it. Then, further, these cost data usually cover only certain items of the total expense, leaving a very considerable amount to be estimated. Among the items usually omitted are:

(a) The cost of the bond required by the contract.

(b) Casualty insurance.

(c) Insurance of plant.

(d) Interest on retained percentage.

(e) Interest on payroll if monthly payments are delayed.

(f) Interest on plant cost.

(g) Depreciation of plant.

(h) General superintendence and engineering.

(i) General office expenses, time keeping, etc.

(j) Traveling expenses and expenses of entertainment.

(k) Legal expenses.

(l) Expenses incidental to obtaining the work.

(m) Expenses of carrying plant and organization over the winter season, and between jobs. This expense is increased by the 8-hour law.

(n) Expenses due to getting plant to and away from the job.

(o) Expenses necessitated by the sanitary precautions required by the contract.

(p) Expenses resulting from remoteness of work, necessitating construction of houses and very permanent camps, particularly on account of very severe winters.

(q) The general expenses about a job such as labor on maintenance and repair of plant.

(r) The expense of materials and supplies of all kinds.

(s) The contractor's profit.

(t) The contingencies of strikes, epidemics, floods, heavy rains on the embankments, the accidents which result in delay; the difficulty of keeping labor on the work; the possibility of very wet excavations; the possibility that the Ulster & Delaware R. R. may not be removed on time; the possibility that a deficiency of embankment material Class C might be required to be made up by quarrying and, conversely, the possibility that an excess of it would have to be wasted; the possibility that much or all of the sand necessary for the masonry would require screening or washing, or both, and the thousand and one other contingencies met with on every work.

(21.) The knowledge that in nearly every case of which the engineers of the Board had personal knowledge, the data of its cost given in a well-known handbook were not only misleading but positively erroneous.

(22.) The absolute unanimity of opinion among all of the engineers of the Board and the concurring belief of every engineer outside the Board with whom conversation was had, that the bid of the John Peirce Company was so low that to accept it would simply be to invite delay with all of its attendant litigation and a resulting cost higher than the tender of the second bidder.

(23.) Consideration was also had that:

(a) The prevailing rate of wage for common labor during the life of the contract would be not less than $1.50 per 8-hour day.

(b) The probability that the average market price of materials during the life of the contract would be the same as it was when the estimates were prepared.

(24.) The evidence offered by the tenders of the four higher bidders, also, could not be overlooked. These four bids were prepared at the expense of time and money on the part of the contractors, who gave every indication of an earnest desire to secure the work. These contractors in order to confirm the estimates of their own men engaged other engineers to estimate for them on the work. Six engineers were so engaged and their reputations were well known to the chief engineer.

Every particle of evidence, therefore, pointed unerringly to the patent fact that an error had been made in the preparation of the bid of the John Peirce Company and when Mr. Peirce himself admitted that his price was "too low to do satisfactory work for myself or the city" the chain of evidence was complete.

Emphasis should be laid on the fact that these estimates were not made for the purpose of giving the Board of Water Supply an idea as to the cost of work so that an appropriation therefor could be made. These estimates were prepared as nearly as possible as a contractor prepares them. They were made for the purpose of gauging the bids received as to their reasonableness and sufficiency.

Estimates of Messrs. Moore and Gregory.—In estimating the probable cost of the main dams of the Ashokan reservoir, due allowance was made for the effect of the 8-hour day. When this estimate was made the demand for labor was in excess of the supply, a great many millions of dollars' worth of large engineering construction being in progress or contemplated, not only by the Board of Water Supply, but by the State for the barge canal and highways, by the great railroad systems entering New York City, and for proposed additional subways and bridges in Greater New York. The 8-hour law and this great demand were expected not only to increase the price of labor, but to decrease its efficiency, as has been demonstrated by experience.

The cost was also estimated to be greater than in some other places because of the location of the work on a railroad running through difficult country with excessive grades, where the cost of operation is high. This, combined with lack of competition, makes a high freight tariff. Moreover, this railroad, crossing the sites for the Beaverkill dike and the inlet channels four times, will prevent economical work. Experience elsewhere has shown that the satisfactory adjustment of a railroad relocation under like circumstances requires years, and in this case may possibly not be accomplished until all other work is approaching completion. Necessity for maintaining traffic will require additional construction tracks, trestles, and plant, by dividing work otherwise handled as a unit.

The Ashokan dam sites are in a region where winters are severe. The cost is increased by the shorter actual time of operation of the plant, and carrying over the more skilled portion of the organization while not employed to the best advantage.

To get an understanding of the conditions affecting the cost of the dams, certain factors bearing on individual items were brought out by study of the specifications and the physical limitations.

Item 4 in the specifications, earth from trenches with vertical sides, less than 20 feet deep, mostly compact boulder clay, will have to be excavated by picks and shovels and hoisted out of the trench by derricks. The cost of excavating under conditions obtaining for these trenches will not differ from that for sewers or water pipes in similar material. The estimate was not compared directly with any similar work but checked somewhat by the similar item in the Croton Falls dam.

Item 5, earth from trenches at a depth greater than 20 feet, is expected to be taken almost wholly from Beaverkill gorge. The more extensive plant, the restricted space, the greatly increased lift, and the anticipated inflow of water, are the principal factors making the cost greater than under Item 4. The estimated cost was reached by considering the difficult factors and conferring with engineers experienced in similar work. Another consideration affecting both items 4 and 5, is the necessity for preserving the sides and bottoms of some trenches in absolutely sound condition to receive masonry.

Item 6, earth principally from the channels also from areas adjacent to the dividing weir and from the masonry portion of the Olive Bridge dam, is mostly compact boulder clay. Parts of the channels contain a large proportion of boulders, and although they may be excavated by steam shovels, some of the material will probably require blasting, and much water will be encountered. If steam shovels are used, it will be difficult to supply adequate transportation while making the first cut. The haul is long and the grades steep. The estimate was based in part on investigations of the cost of steam shovel work and in part on the cost of excavation for the Chicago drainage canal, the New York barge canal, the West Neebish channel near Sault Ste. Marie and the Panama canal. Ten cents per cubic yard was allowed for the use of portions of this material for building embankments, on the assumption that about half of the total excavation of this class could be delivered on dikes where it would have a net value of about 20 cents after deducting the additional cost of this operation.

Item 8, rock from the foundations of Olive Bridge dam, the weirs and the pressure aqueducts, is to be excavated without blasting, except where especially permitted. The excavation for Olive Bridge dam will be subject to flooding, and a great deal of pumping will be necessary to take care of seepage. Great pains must be exercised to obtain sound, tight, unshattered rock upon and against which to build the masonry. About half of this work was estimated at the rates for rock excavation without blasting at the Cross River, Croton Falls, and Wachusett dams and the rest at a little more than ordinary rock excavation.

Item 9, rock from the channels and the foundations for the gate-chamber, will be excavated from large, deep trenches having definite shapes, and payment will be made to prescribed lines. In other respects this work will not be unusually difficult and the estimated cost was based on work at other places.

Materials for embankments and refills are classified under five items in order to adapt their physical characteristics to special requirements. The greater part of the embankments is included in items 12, 13 and 14, much of the materials for which must be obtained from borrow pits of boulder clay located on the hills downstream from the dams. This material must be carefully separated into the proper classes. Removing the stones, of which there are 10 to 20 per cent., will make this work more costly than for several dams the prices for which are known.

Item 12 is embankment and refill made from selected, fine, impervious earth wetted and rolled in 4-in. layers, from which all but small stones have been removed. Placing of materials, removal of stones, and necessary arrangements for wetting are all more expensive than usual on account of the large dimensions of the dikes and their length of nearly 4 miles. The water supply will require pumping plants, and an extensive piping system frequently shifted. The rolling requirements are exceptionally strict, as the more than usual height of the dikes requires that every precaution be taken to obtain watertight work, free from settlement.

The estimated cost was reached from study for nearly a year of methods and costs under conditions that exist at Ashokan, considered as divided into two parts: (1) excavation and transportation to dikes, and (2) spreading, sorting and compacting. To determine cost of excavating and transporting, an examination was made of all available data on cost of excavating and transporting, by steam shovels and trains, covering about forty different records. From this list selected examples most similar to the work at Ashokan were given more weight. Much material of the Chicago drainage canal was boulder clay somewhat similar to that at Ashokan. Some of the first prices for excavating this material were between 25 and 30 cents per cubic yard, but in a number of cases, the contractors failed and the work was relet at much greater prices, in some cases, double the first price. Section E was completed at the original price, but the contractor made no profit at 26¾ cents; part of this excavation was comparatively easy, and some large daily records were made. Considerable weight was given the cost of steam shovel work at Panama and the building of large embankments at Washington, D. C. Many other costs, when proper allowance had been made for different conditions existing at Ashokan, showed the cost of excavating and transporting would be somewhere between 20 and 30 cents per cubic yard depending upon the method of distributing the material upon the dikes. If the material was simply hauled to a central dumping station, it was estimated that this could be done for about 21 cents. If, on the other hand, it were taken out on the dikes and dumped directly from the cars on to the work, the additional delays and track expense would raise this cost to about 30 cents. The cost of distribution and compacting was influenced by the contract prices at Croton Falls, Cross River, Erie Canal, and somewhat by costs of the dams of the Metropolitan Water Works. The contractors made no profit on many of the contracts of the Metropolitan Water Works; the contract price for the Sudbury dam was practically a cost price. The cost of the Tabeaud dam was considered, where conditions were unusually favorable and the plant ideal. Hauls were short and cost of teams for transportating and digging very low. The actual cost of dam was given as 40 cents per cubic yard. Reducing this price to Ashokan conditions indicated a price as great or even greater than the one used.

A synthesis of cost of this item was also made based upon information contained in Gillette's "Costs of Earthwork," and a cost built up that roughly agreed with the prices otherwise obtained. A plant was laid out for doing this work; the cost of machines and tracks, operation, and common labor was estimated; conservative outputs for machines and laborers were assumed, and in this way another cost for embankments built up. The price finally used was not based specifically on any one of these studies, but upon judgment that was the outgrowth of these studies and also the opinions of various contractors and engineers.

Item 13 is embankment and refill made from earth, whether impervious or not, wetted and rolled in 6-in. layers, from which all but small stones have been removed. The unusual expenses incidental to Item 12 apply to a large degree, and the cost per cubic yard will probably be little less. It was estimated in the same way as Item 12.

Item 14 consists of durable boulders, stones and rock fragments placed on the faces of the embankments, and includes a layer of clayey earth on top of the stones on the downstream side. The greater part of these stones will probably be sorted from materials excavated for Items 12 and 13; some may come from rock excavations, but any lack of suitable stones must be made up by quarrying. This material will be hard to handle. The greater part must be loaded by hand whether it comes from the embankments or from quarries; some of it must be transported from considerable distances. The portions near the faces will require re-handling to conform to the designated slopes. On the upstream slopes larger stones will have to be selected and put on the outside to resist wave action. On the downstream slopes smaller stones will have to be used to fill interstices of the larger stones so as to support the layer of clay. Unsound stones must be removed. It was estimated in the same way as Item 12.

Elsewhere embankments for retaining water have usually been built by hauling suitable earth in carts from borrow pits located at no greater distance than the width of the largest of the Ashokan dikes. Sorting and placing is usually accomplished by the exercise of intelligence by the foreman or laborer. Where teams are loaded by hand, only the kind of material required is thrown into the wagon to be placed at the point where material of this kind is needed. The greater part of the material for the Ashokan dikes must be transported long distances over steep grades. The necessity for different arrangements and even types of plant at different places and stages of the work, the rate of progress required and the size and complexity of the plant and organization demanded by the very magnitude of the operations, were found to be important elements affecting cost. The core-walls, since they must be carried up in advance of the earthwork, will divide the embankments longitudinally, thus interfering with transportation and compacting. Adjacent to each side of the core-walls, the materials will have to be placed and compacted at least partially by hand. These things were all considered in reaching the estimate.

While some excavated materials will be suitable for use in embankments or masonry directly, there is doubt whether in the majority of cases it will not cost more than to take materials as needed from borrow pits and quarries. This is especially true of the earthwork, for much of the excavation must be done before any considerable quantities of materials can be placed in embankments. Hence it will be necessary to place most excavated materials in storage piles before it can be used.

Masonry items were based largely on contract prices for Cross River, Croton Falls and Boonton dams, and Catskill aqueduct. Some consideration was given to reported profits or losses on Cross River dam. Portland cement was based on the market price at the time, to which was added a nominal amount for cartage and storing; also the price bid for Peekskill division of Catskill aqueduct. The costs of constructing cyclopean and concrete masonry were analyzed sufficiently to indicate the influence of a slight increase in the cost of sand and stone over that at Cross River and Croton Falls.

The items considered in detail above constitute 96 per cent. of the contract, divided as follows: Earth and rock excavation, 19 per cent.; embankments, 33 per cent.; masonry, 44 per cent.

Five Steam Trucks are used by the London (England) County Council for distributing tramway supplies, and for hauling sand. One truck is held in reserve, and the other four cover 3,200 miles per month and carry 690 tons, or about 170 tons per truck per month.

The Weehawken Transfer Bridges of the West Shore Railroad.

The New York Central & Hudson River R. R. Co. has during the past year constructed and placed in service two double-track timber transfer bridges at the north end of its West Shore terminal at Weehawken, N. J. They are designed for service in handling the transfer of cars, principally freight cars, by means of floating equipment, and are operated in conjunction with the yard lay-out of the terminal, which is adjacent to a long line of large piers, the tracks from which, like those from the transfer bridges, connect with a very long and large yard which provides for transfer, storage and distribution of a great number of cars. The operation of the bridges is almost entirely confined to the eastbound interchange business of the railroad company in connection with its bridges at the foot of West 33d St., New York, and with those of other companies having similar facilities on Long Island.

The adjacent bridges and their equipment have the general appearance of a single structure, but are in reality two, entirely independent in their operations; the complete installation includes six elements, namely, the pile platforms, the bridges and aprons, the steel superstructure, the operating machinery, the housing and the pile racks. Before definitely locating and designing the pile substructure, the bearing power of the bottom and the efficiency of the piles were experimentally investigated by driving and loading test piles.

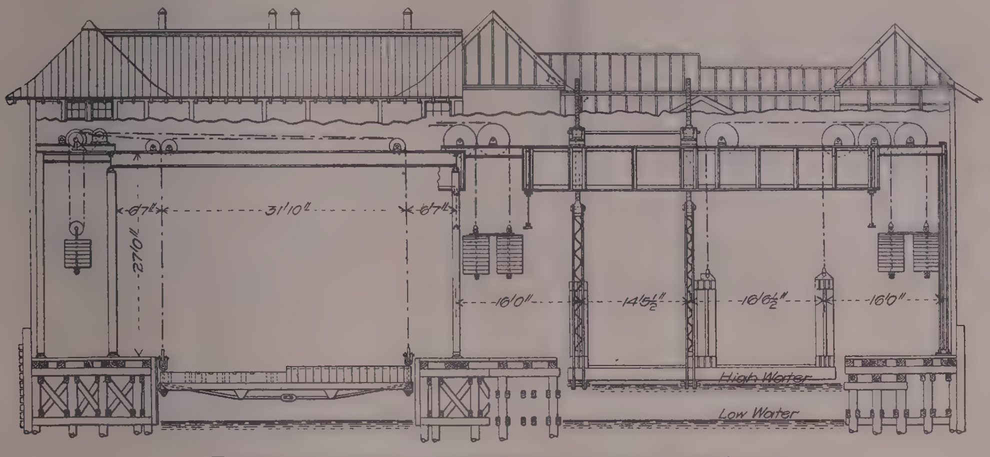
Four yellow pine piles 6 in. in diameter at the point and 15 in. at the butt, and from 75 to 85 ft. in length, were driven in water about 16 ft. deep at the vertices of a 12 x 20-ft. rectangle. The piles were driven with bark on, but were measured under the bark. The bottom was of mud, very soft on top, and the piles were driven by a 3,800-lb. hammer with an effective fall of about 6 ft. The piles penetrated 27 or 28 ft. under their own weight alone, and from 10 to 16 ft. farther under the added weight of the hammer without impact. The first 10 to 19 blows on the different piles increased the penetration from 13½ to 23 ft. more, after which 10 or 15 more blows were given, the last 5 blows causing an average penetration of 6 to 12 in. each.

Sixteen days after the piles were driven they were connected together above water level by longitudinal and transverse struts without diagonals and transverse caps were laid on their tops to receive successive cross tiers of 30-ft. rails. Under a load of 5 tons per pile no settlement whatever was observed. With 10 tons two of the piles showed no settlement and the other two showed settlements of 3/16-in. This did not materially change for five days, after which the load was increased to 17 tons, each producing settlements of 1/16 and 3/16-in. in the piles not before settled. The load was then increased to 22 tons each, increasing the settlement to 5/16 to ¾ in. From these results it was assumed that the loads less than 22 tons merely compressed the timber and closed the joints, and that actual settlement did not occur until the full load of 22 tons was applied. A working load of 10 tons per pile was therefore adopted for the piles in the substructure. This is in some cases increased to a maximum of 13 tons, and at the shore end of the structure is reduced to an average of 5 tons each.

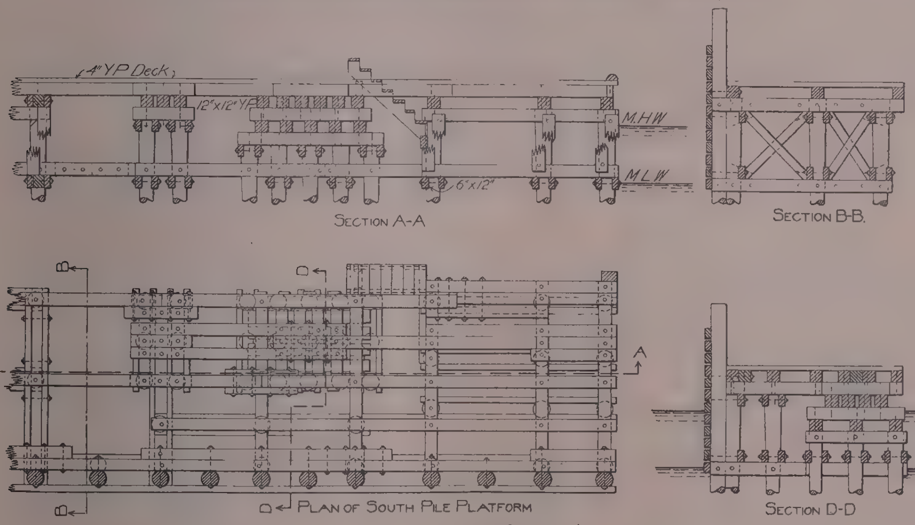
The bridges are placed side by side at the outer end of a pier about 121 ft. wide, which projects about 145½ ft. beyond the bulkhead line adjacent to slip No. 11, 150 ft. wide, to proposed Pier No. 11, 600 ft. long, which projects about 255 ft. farther into the river than does the transfer bridge pier, and thus protects it from the tidal current on one side while corresponding protection on the opposite side is afforded by the north pile rack, 205 ft. long, from the extremity of the pier. The south pile rack, 100 ft. long, separates the transfer boat slip from slip No. 11 and the center rack 48½ ft. long separates the slip into two pockets, one for each bridge, and guides the floats to their respective positions. The bridge slip is made accessible by dredging the river bottom to a depth of 20 ft. below mean low water. The original depth of the water here varies from about 8 to 19 ft., and the dredging was executed with an ordinary dipper machine.

The pier, which is of pile construction, very rigidly braced, terminates at the outer end in a center platform and two side platforms covered by a wooden building in which are located the steel towers and lifting apparatus for adjusting the transfer bridge to correspond with the change of the tide and the height of the float decks. The bridges are duplicate structures symmetrical about the center line between them and are each pivoted at a fixed point at the shore end and adjustably suspended at the river end from heavy steel girders resting on well braced steel towers. The center platform between the outer ends of the bridges carries a counter-weight tower, double mooring gear, and operator's cabin. The extremities of the outside platform carry smaller counterweight towers and single mooring gear. Each bridge has three Howe trusses 11¼ ft. deep over all and about 81 ft. long and 16 ft. apart on centers. The floor is suspended from the lower chords of the trusses and is continued about 25½ ft. beyond their outer extremities by an apron platform hinged to the outer end of the bridge and adjustably suspended at its outer end.

The center trusses are cambered 3 in. and the top and bottom chords are each respectively made with five full-length pieces of 7½ x 14-in. and 7½ x 16-in. Oregon fir, separated 1¾ in. by the



Transverse Section and Elevation of Bridge and Apron.



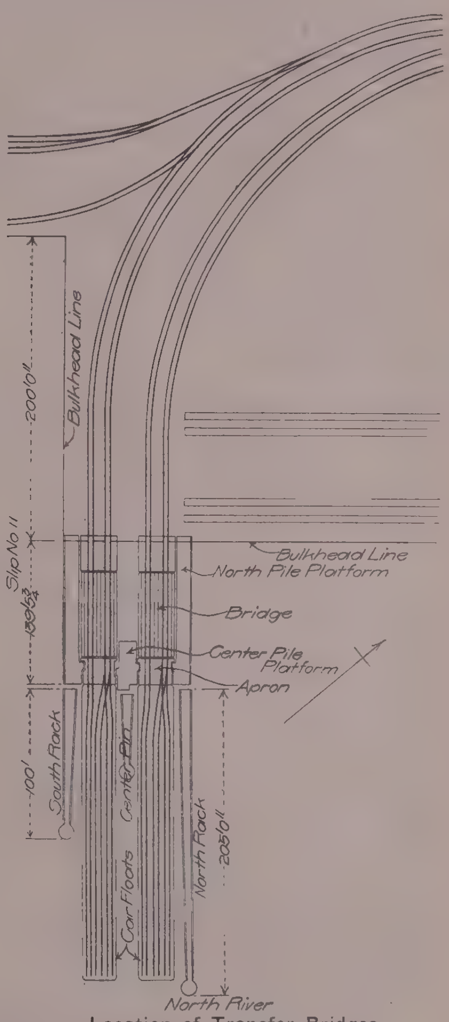
Section A-A

Section B-B.

Plan of South Pile Platform

Section D-D

Main Platform.

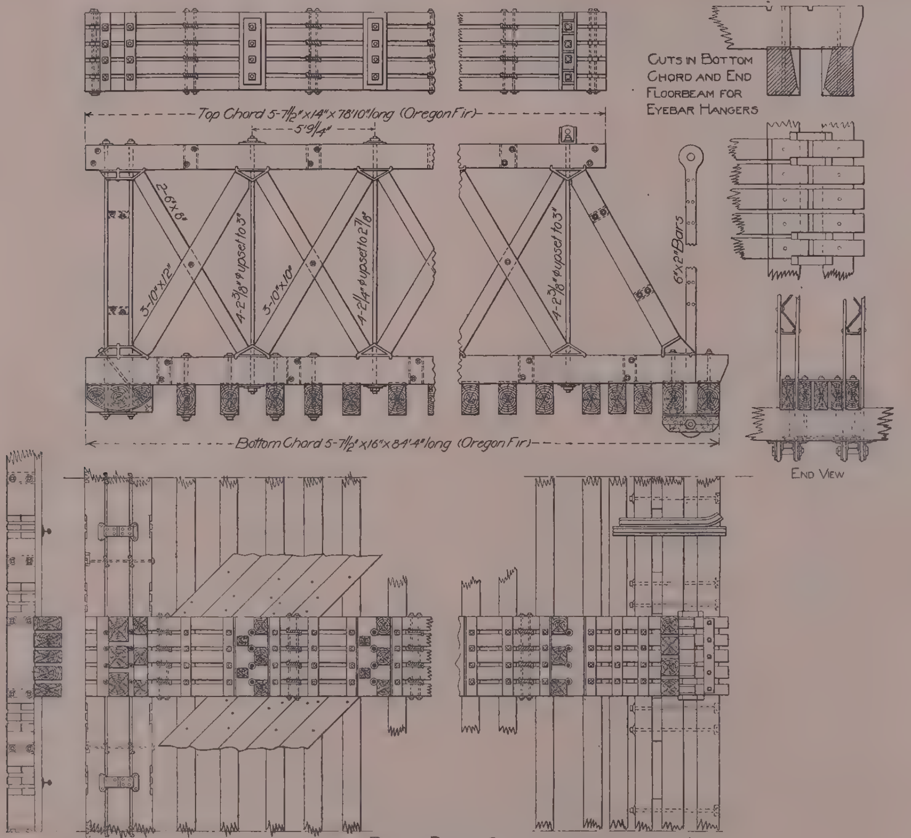


Location of Transfer Bridges.

vertical rods at panel points and, intermediately, by cast-iron filler plates Z-shape in cross section, with their projecting ends gained into the faces of the timber to act as dogs thoroughly secured by pairs of horizontal through bolts.

The diagonal members of the truss vary from four 10 x 12 in. in the adjustable end panel, to two 6 x 8-in. and three 8 x 8-in. in the center panels and are spaced to clear at the intersections where they are connected by a single ¾-in. horizontal bolt. The ends have square bearings on the inclined faces of hollow cast-iron blocks with flanges notched into the chord timbers and ¾ in conical spurs to secure the ends of the diagonals. The vertical members are uniformly four screw rods from 1½ to 3⅜ in. in diameter with upset screw ends and nuts bearing on single and double horizontal washer plates, except at the end where there are eight 1⅛ in. rods. The track rails are spiked directly to 10 x 18-in. floor beams 35 ft. long of Oregon fir, each of which is suspended in the midle by four 1⅜-in. vertical bolts passing through the spaces between the chord timbers and through holes bored in the floor beam with nut and head bearing on top and bottom horizontal washer plates.

The three 12 x 16-in. oak floor beams at the shore end are spaced 1 in. apart and bolted together with 1-in. horizontal transverse bolts. The lower surface is rounded, in ten places, to a radius of 24½ in., and faced with steel bearing straps to match the corresponding steel plates on the concave surfaces of hollow quoin blocks fixed to the end of the pier at mean high water level. This arrangement provides a pivot for the revolution of the bridge about 9 deg. in the vertical plane, and distributes the total load of about 650,000 lb. over a bearing surface of about 30 sq. ft. From which it is directly transferred to 40 piles 90 ft. long, driven with a 4,500-lb. hammer, which in some cases sufficed to drive them by its dead weight alone, without impact.


Top Chord 5-7½"x14"x78'10" long (Oregon Fir)
5'9¼"
2-6"x8"
3-10"x12"
4-2⅜"φ upset to 3"
3-10"x10"
4-2¼"φ upset to 2⅞"
4-2⅜"φ upset to 3"
6"x2" Bars
Cuts in Bottom Chord and End Floorbeam for Eyebar Hangers
End View
Bottom Chord 5-7½"x16"x84'4" long (Oregon Fir)
Plan of Bottom Chord

End Panels of Bridge Truss.

At the adjustable end of the bridge two 12 x 18-in. floor beams are bolted together with an 8-in. filler, and are provided with two riveted shoes, with pins engaging the lower ends of pairs of vertical 2 x 6-in. eye-bars latticed together. The upper ends of the eye-bars are connected through 5½-in. pins to vertical screw rods 6½-in. in diameter and 17 ft. long, with a double square threads 15½ ft. long which engage bronze nuts 8½ in. thick, forming the hubs of worm wheels, supported in a fixed position on the counterweight tower girders and operated by a worm gear to raise or lower the bridge.

In order to prevent danger of bending the screws when the bridge is in extreme position, the pin connecting the eyebars to the screws is extended and provided with a special cast-steel nut grooved to engage vertical guides attached to an A-frame rigidly connected to the girders above. This detail was designed by the contractors, who guaranteed satisfactory operation for one year.

The greater part of the weight of the outer end of the bridge is carried through four 2⅜-in. vertical rods with 3-in. upset screw ends at the panel point, which form a regular truss member, and at their upper ends engage a special cast steel washer bearing which is provided with vertical transverse webs bored with a 2 5/16-in horizontal hole, which makes it serve as a hanger connection engaging a pin which receives the sockets of two 1⅜-in. cast-steel counterweight ropes for the center truss and two 1⅜-in. ropes for the side trusses. The trusses are proportioned for a dead load of 1,800 lb. per lin. ft. and for a live load due to a continuous line of 100,000-lb. capacity pressed steel cars with 40,000 lb. axle loads spaced 5 ft. 7 in., 16 ft. 8 in., 5 ft. 7 in., 6 ft., 5 ft. 7 in., 16 ft. 8 in., 5 ft. 7 in., 6 ft., 5 ft. 7 in., 16 ft. 8 in., etc.

The outside trusses are similar to the center trusses and are assumed to carry a dead load of 1,100 lb. per lin. ft. plus their proportion of the live load. The top and bottom chords are made with four 6 x 14-in. Oregon fir timbers 78 ft. 10 in. long, and the bottom chord with four 6 x 16-in. Oregon fir timbers 84 ft. 4 in. long. The other members of the truss have cross sections correspondingly smaller than those of the center truss. The track rails have a butt joint with 1 in. clearance over the center of the roller log, where they are seated on a cast steel chair with a concave bearing in the top of a cast steel shoe bolted to the roller log concentric with the curvature of its bearing in the hollow quoin.

Finished Bridges and Operating House.

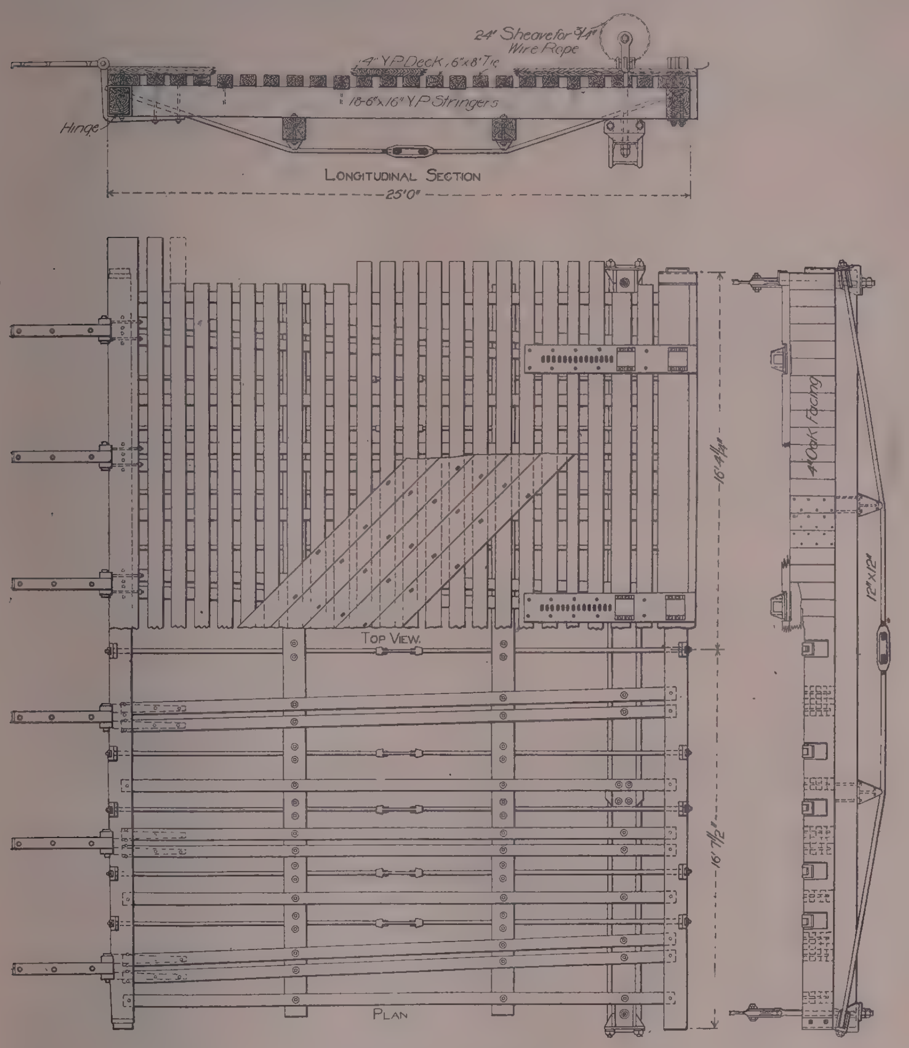
Connection between the bridge and the car float is made with an apron platform 25 ft. long and 34 ft. wide hinged to the outer end of the bridge and supported by steel suspension cables at its extremity. This apron has eighteen 6 x 16-in. yellow-pine stringers 24 ft. long connected through their truss rods to the 12 x 16-in. end floor beams. Intermediately the stringers are connected by two 12 x 12-in. transverse timbers 32 ft. long bolted across their lower sides and serving as continuous pedestals for the cast-iron saddles receiving the bent truss rods. The shore end floor beam is provided with six pairs of heavy bent steel bars bolted to the stringers and forming one-half of the hinges which have their other leaves bolted to the end of the bridge. A 12 x 12-in. transverse timber 33 ft. long is bolted to the lower sides of the stringers near their outer ends and receives at its extremities the cast-iron bearing for nuts on the lower ends of vertical forked eye rods having 24-in. iron sheaves in the bight of the ¾-in. steel suspension rope supporting the apron from the counterweight tower girders.

Four 15 x ¾-in. longitudinal bed plates 7½ ft. long are bolted to the floor on the outer end of the apron and are each fitted with two cast-steel housings through which 5 x 5-in. horizontal forged steel toggle bars 6½ ft. long slide on the bed plates and engage locks on the deck of the car float. The toggle bars are operated by levers passed through slots in their rear ends and engaging transverse holes in the bed plates which enable them to be pinched back and forth.

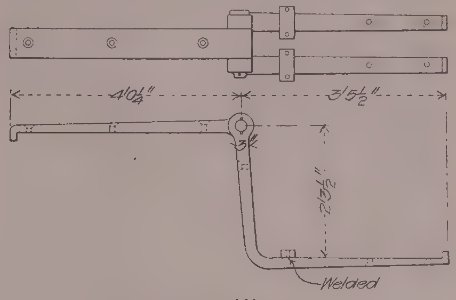
The suspension rope for the outer ends of the apron is a ¾-in. wire cable about 278 ft. long which terminates at both ends in an eye engaging a 2-in. horizontal pin through a pedestal seated on the top flanges of a pair of 10-in. channels 4 in. apart back to back, that are carried by the main girders of the counterweight frame. The cable passes down between the channel webs and around the counterweight sheave, then up to and several times around a drum, thence horizontally to a guide sheave, vertically down around one of the apron sheaves, up again around another guide sheave seated on the tower girder, and horizontally across the bridge to a second similar guide sheave and from it down and around the second apron sheave, up again and horizontally over a guide sheave and thence several times around a second drum, vertically down around the counterweight sheave and up to the top of the tower where the second end is engaged on the same pin that receives the first end. By this arrangement the rope passes over a double sheave at the counterweight and vertically above it and around five other sheaves and the operating drum, thus making a funicular machine in which all stress is equalized.

The outer end of the bridge is supported by eight separate short ropes run directly from their connections to the top chords over the four double pairs of guide sheaves supported on the upper girders of the counterweight tower and vertically downward to the counterweight. The counterweight of the apron weighs about 20 tons, and consists of cast-iron plates 3 ft. square and from 4 to 12 in. in thickness with 3⅛ in. holes, cored in the center to receive a 2¾-in. vertical rod 11 ft. long with a double nut and washer at the bottom and a forked eye at the top, engaging the counterweight sheave. The counterweights for the bridge are made with cast-iron plates 40 in. wide and 5 ft. 8 in. long and weigh 5 tons. Each plate is made in halves with grooves and slots in the upper surface to receive the connection bolts, as indicated by the details. They are cored with 2¼ in. holes for the vertical suspension rods with double nut bearings on saddle plates across the lower flanges of transverse beams supporting the counterweight and having eyes at the upper ends connected to clevises on the ends of the cable.

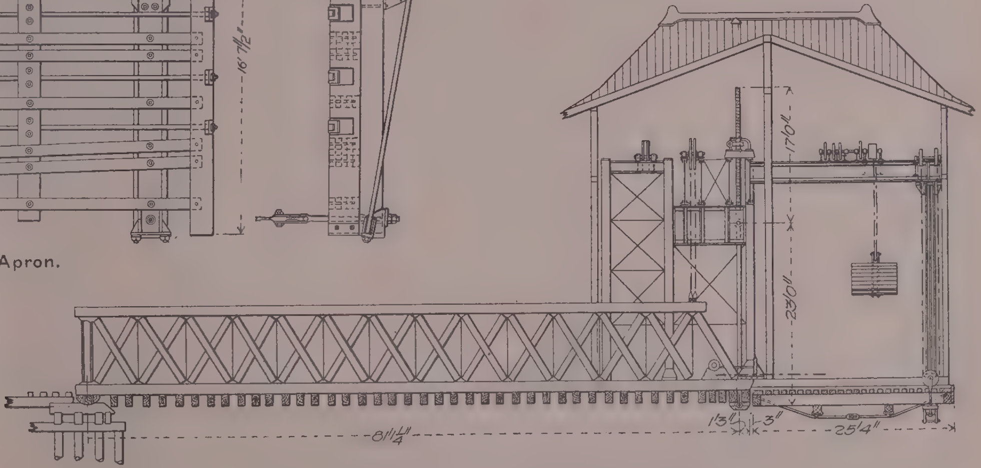
The racks on both sides of the slip are of special construction made with double pairs of con-



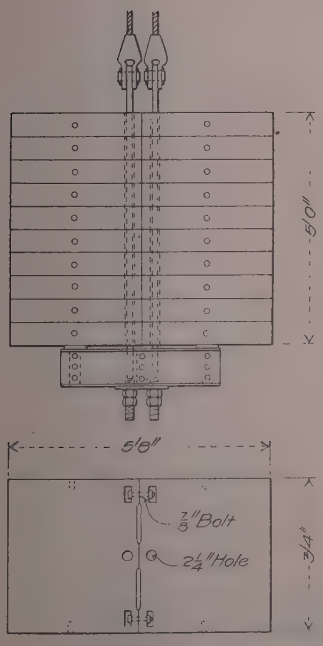
Details of Apron.



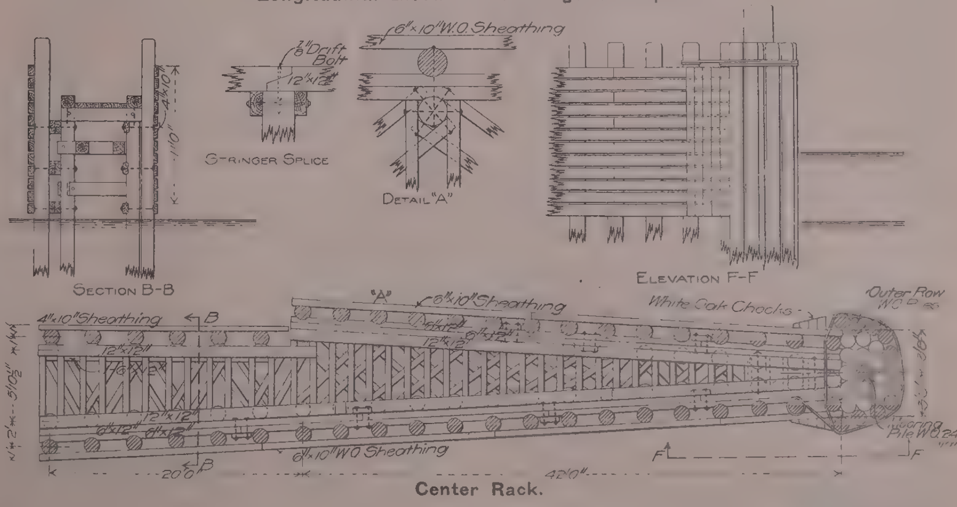
Apron Hinge.



Longitudinal Elevation of Bridge and Apron.



Counterweight.



Center Rack.

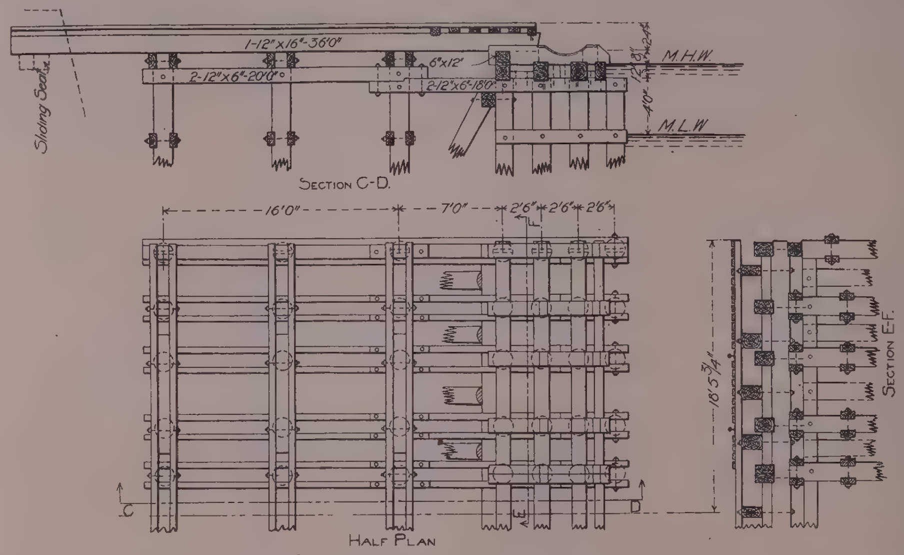
verging rows of piles very firmly braced together. The outer piles are sheeted with 6 x 10-in. horizontal white oak planks extending down to mean low water line. The outer end of each rack terminates in a large cluster of piles driven solid close together and bound at the top with several turns of a 1½-in. steel cable. The center pile of the cluster is 24 in. in diameter and about 55 ft. long and projects 3 ft. above the top of the cluster, where it is cased with 4 x 4-in. white oak to serve as a mooring pile. The horizontal braces are in pairs secured to opposite sides of the pile with ¾-in. through bolts. The stringers are double, with staggered lap-joints spliced with outside clamp pieces tightly bolted.

The counterweight towers and overhead girders carrying the sheave for the extension rope are of structural steel corresponding to high-class bridge work. The pier house has a heavy timber framework thoroughly braced and a roof carried by Howe trusses 38 ft. long, made with 18 x 10-in. spliced top chord pieces cantilevering 6 ft. beyond each end panel bolt and supporting continuously a 2 x 10-in. yellow pine ridge timber. The bottom chord is a single 8 x 10-in. yellow pine timber about 40 ft. long, knee braced to the top of the supporting columns by 5 ft. corbels at each end. The principal quantities involved in the construction are 500 piles, 200,000 ft. B. M. of timber, 100,000 lb. of castings, inclusive of machinery, and 230,000 lb. of structural steel.

The shore ends of the bridges are hinged to spring platforms with their longitudinal stringers at the opposite end, sliding on the bulk head sills so as to act as buffers without transmitting the impact from boats to the bulkhead. Each platform has two tracks with two 12 x 16-in. stringers 2 ft. 5¼-in. apart.

The bridge and apron have a combined vertical range of more than 11 ft., and speed tests gave a vertical movement of about 9½ ft. per minute up or down for the apron, and about 4 ft. for the bridge. The apron is connected to the bridge with very heavy forged strap hinges which have transverse keys gained into the timber, and have one leaf bent 90 deg. around the end transverse beam. A special system of tracks and switches on the apron permits the cars to be diverted to the center track of the float, within a shorter distance than is said to be afforded by other transfer bridges in the vicinity, thus improving the clearance on the floats. Imperfect connections between floats and transfer bridges often cause great wear and tear, and it has been suggested that all companies operating such equipment in New York harbor adopt uniform standards for both.

The construction above described was designed in accordance with the requirements and specifications of the New York Central & Hudson River Railroad Co. while Mr. W. J. Wilgus was vice-president, Mr. H. Fernstrom chief engineer, and Mr. G. A. Berry engineer of bridges. Since the plans were begun Mr. Fernstrom resigned and Mr. G. W. Kittredge succeeded him. It was built under the supervision of Mr. A. W. Carpenter, engineer of structures, and Mr. R. E. Dougherty, resident engineer, by the Butler Bros.-Hoff Co., New York.



Support of Shore End of Bridge.

A Notable Rolling Mill Engine has recently been built for the Carnegie works of the United States Steel Corporation that ranks among the largest reciprocating engines ever built. It is a horizontal twin tandem engine, with 42 and 70 by 54 in. cylinders, designed for operating condensing with steam at 175 lb. and for a maximum speed of 200 r.p.m., at which speed it has a maximum capacity of 25,000 h. p. The engine erected has a total weight of 550 tons, and some of the individual parts are very large, two of the frame castings weighing after machining, 118 tons each and requiring special reinforced cars for their transportation.

Hysteria in Regard to Pavements.

By Clifford Richardson, New York.

The daily and, occasionally, a portion of the engineering press has voiced for some years the most extravagant, and generally inspired, statements in praise of now one form of pavement and now of another, but generally of some form which is more or less of a novelty and which has not been subjected, under any difficult environment, to the test of time. This praise of one form, usually united with condemnation of others, has become a kind of hysteria, a hysteria which is one of our commonest faults in politics, in our amusements, and in our consideration of anything which is a novelty. No better example of this can be cited than the manner in which the possibilities, expectations, and predictions of what liquid air was to do in revolutionizing our industries were exploited but a few years ago.

There has been a like tendency to look at the problem of paving our streets. There has been a neglect of a proper consideration of this problem and of the available evidence in regard to the merits of different forms of pavement. Too much reliance has been placed upon partisan statements emanating from the promotor, the contractor, or the enthusiastic advocate, without regard to actual service tests of the form of construction under consideration. It recalls the ease with which a person, by staring strenuously in one direction at nothing for some time, can assemble a mass of persons, who, looking for novelty, are only too eagerly led by curiosity. The novelties in forms of pavements which are only too frequently put before the public are creations of this description. People flock to advocate their merits with an eagerness which depends upon the inducement held out to do so, or the desire for something new, although the actual value of the pavement can only be determined by service tests.

Some years ago, brick pavements attracted a great deal of attention and were heralded as the solution of the paving problem. Their construction was entered into on a very large scale, since the demands of the people could not be resisted. The brick manufacturer was eager to turn out bricks to fill the demand, but he gave little thought to the character of his product. A large portion of it was quite unsuited for paving purposes, which, added to the unsatisfactory way in which the foundations were constructed and the brick laid, resulted in pavements which wore out rapidly and caused a general revulsion against them. To-day, experience has taught the manufacturer to make a better brick, and the engineer and contractor how to lay them. It has also shown the limitations of this form of pavement and that it must be confined to streets of light traffic. Had the introduction of brick pavements proceeded more slowly, the vast amount of money wasted in them might have been saved.

The same situation exists to-day in connection with the exploitation of creosoted wood block pavements. Nothing is known as to their ability to withstand heavy traffic and all the evidence derived from experience with this class of pavements abroad points to the conclusion that their life, even when the blocks are of the thickness in use in London and Paris, is short, from five to seven years. In New York City, where much thinner blocks are in use, 3½ in., as compared to 4½, 5 and 6 in., far from good judgment has been shown in constructing the large area of such pavements which has been laid in the past two or three years. The results will be interesting as an experiment, but may, and probably will, prove very expensive to the city.

The history of that type of pavement known as bitulithic, bituminous macadam, and by other similar names, is also instructive. About 16,400 sq. yd. of it were first laid in 1901. Although nothing was known as to its life, and although coal tar pavements had always proved failures in the past, the public plunged in 1903, according to the advertisement of the promotors, to the extent of 915,630 sq. yd. in an untried material, and even now continue to do so, notwithstanding the fact that this form of construction has proved a failure, on streets of very medium traffic, when laid with coal tar as the cementing material.

The situation to-day in regard to all forms of pavement so far as the public, and much to the same extent so far as municipal engineers, are concerned, is such that it is impossible for them to determine wherein the true merits of any form of construction lie or whether there are any inherent defects in it. There has been a continuous tendency to be led by the specious and hysterical claims of the advocate of the latest novelty, merely for a change from some standard form which in particular instances has not been entirely satisfactory, owing to the construction of surfaces of a type not suited to the environment to which they were submitted, or to lack of maintenance on the part of the municipality.

The situation is also to be attributed to the fact that there is not a sufficient interchange of the results of experience between different cities and different countries, and to an unwillingness to be guided by the experience of others. Each municipality prefers to carry on its local experiments and is only convinced that some form of construction upon which it has placed great reliance is not successful when failure is demonstrated at its own expense.

How much has the United States benefited by the experience of London, Paris or Berlin? Even in those cities, a different policy is followed in each case. Berlin is largely paved with rock asphalt, because that form of construction is well done there, and the city sees to it that the surfaces are properly maintained and not allowed to deteriorate. Berlin will have nothing to do with wood pavements, having found by experience something which it believes to be better and more economical. Rock asphalt pavements are not considered satisfactory in London and Paris. The reason is not far to seek; they are not well constructed in those cities. Wood pavements are favorites in London because, although they are very expensive, it is well known exactly what is being obtained for the money expended, even if the surface must be renewed in from five to seven years on streets of heavy travel. Paris is looking for something new, not being satisfied with anything now in use as constructed by Parisian contractors.

In the United States, one of the main difficulties in connection with the paving problem is the lack of appreciation of the fact that a pavement has a more or less definite life, which cannot extend over an indefinite period of years, and that it must be replaced at the end of that period. This difficulty has had its origin in the fact that pavements are, for the most part, a relatively new thing in many of our cities. The streets are being paved for the first time, and in large areas, at great expense. There is probably no city in America in which the entire area of the streets is paved, so that the problem can be taken up as a continuous one of maintenance and replacement. In most of them, the available revenue must be devoted to new work on streets which have never been paved, and an insufficient amount, or nothing, is left for maintenance of surfaces on which the contractor's guarantee has expired. The result is a great deterioration of the pavement, with the impression on the public that the kind of pavement is a poor one, which may be quite erroneous. As an example, a city official of an eastern city, in response to inquiries from a committee of the Society of Municipal Engineers of New York as to the cost of maintenance of asphalt pavements in that city, replied that "the amount expended per year depended upon the annual appropriation rather than upon the needs of the streets." The same thing is known to be the case in many other cities. The available revenue is mostly spent for new work and in an insufficient amount for maintenance.

Another very serious matter in connection with the paving problem in the United States is the fact that the standard of construction in this country is not of the highest. The enormous areas to be paved and the limited amount of funds available for this purpose necessitate the specification of a form of construction which is, in the end, far from being the most economical, although it permits the immediate improvement of a greater area. This is most unfortunate and results in work which is a discredit to the particular type of pavement so constructed. A well-known French government engineer, in commenting on American roadways which he examined officially in our leading cities at the time of the St. Louis Exposition, has remarked, after a close study of the system on which our asphalt pavements are constructed, that it was far superior to that in use in France, but that the very numerous defects in such pavements which he observed were due to the deficiencies in the form of construction specified by the municipalities and not to anything lacking in the system upon which such pavements should be constructed under proper specifications. These remarks will apply as well to other forms of pavements in America as to asphalt. It will only be when our municipal engineers wake up to an appreciation of the true economy and advantage of specifying a form of construction of the highest grade that our streets will be free from defects and the criticisms to which they are now open. With this must, however, be combined a proper provision for maintenance and, more particularly, for the prompt replacement of the pavement where openings have been made for underground connections. Where such openings are neglected, it conveys to the public the impression that they are due to defects in, or failure of, the surface of the pavement owing to poor construction, when this is not actually the case.

No mater what form of pavement is to be laid, it is of primary importance that the foundation or base be of the best description, and of a nature which will carry, without vibration, all the traffic to which the street may be subjected for generations, and this is too often neglected, as in the Borough of Manhattan, in New York. It is true economy, first and last, to construct such a foundation in the first place to support the immediate surface which is being laid, and, in the second place, to avoid the reconstruction of the base when the surface is renewed, or when travel increases to such an extent as to make it an insufficient support. No pavement will resist traffic if it is subjected to vibration and this can only be provided against by the construction of a rigid foundation.

All pavements are of value, but their economy is dependent upon the returns which they give for the expenditure incurred in their construction. What this may be can only be learned by service tests; that is to say, the determination of the cost of any form in relation to the amount of traffic which it will carry before it must be replaced, together with the cost of maintenance during that period. Such tests must, naturally, extend over a long period of years, and much more extended and valuable data are, therefore, available for the older forms of construction than for the more recent and experimental ones. The final question is, has the pavement in question given an adequate return for the money expended upon it from the time of its construction until the necessity for its replacement arises, and is it satisfactory to the eye, ear, and, hygienically, is it readily cleaned, easily maintained, and does it offer ease of traction? Few or no data have been accumulated in the United States which have a bearing on this problem and it is in this direction that most profitable work can be done.

Mr. Nelson P. Lewis, M. Am. Soc. C. E., in his discussion of the question, "Will the Paving Materials of the Present Be Used in the Construction of the Pavements of the Future?" at the Annual Convention of the Society, on July 10, 1907, made a very valuable contribution to the subject. He says:

"This question, as the speaker understands it, is calculated to invite discussion or speculation as to whether or not the popular, successful pavement of the future will be one of those now generally in use, or whether something new will be evolved or developed. Almost every pavement is an evolution. An interesting thought has been brought out concerning another cheap bituminous pavement consisting of asphalt laid on, or mixed with, the ground. Here is a reversion to the discovery of the adaptability of asphalt for street pavements or road surfaces. The rock asphalts of Europe, being hauled in carts for the purpose of making cistern linings, it was found that material which dropped from the carts, when mixed with the natural road material, formed a smooth, elastic and excellent roadway. This was probably the first asphalt pavement, and observation of the effect of the accidental deposit of asphalt on this road led to the construction of the first European rock asphalt pavement; and after half a century, we are going back to this accidental type of roadway which brought about the development of the present asphalt pavement. This shows that, after all, bituminous pavements are the result of discovery and chance as well as of evolution.

"In the speaker's judgment, the great trouble with the development of a new paving material is the disposition of the contractor or discoverer to exploit it before he understands it thoroughly. Reference has been made to wood pavements, beginning with the Nicolson block, made of the cheapest material and laid in the most indifferent way. Several cities in the United States had very unfortunate experiences with this pavement, one becoming practically bankrupt through laying large areas of these short-lived blocks. In America this gave wooden pavements a 'black eye' for years. There is now a revival of wooden pavements, and there are evidences of the same disposition to exploit them by laying as many yards as possible at as good a price as can be secured through any influence that may be available. The greater area laid, the more indifferent seems to be the workmanship and the less care seems to be given to the selection of matrial, so that it will occasion little surprise if this material which is capable of making an admirable pavement is abused to such an extent that there will be a reaction against it in a very short time.

"The adaptability of asphalt has been marvelous; it is found in successful use from Manitoba to the Tropics; in the severe frosts and storms of the North, and in the hot, moist atmosphere of the South. Under the conditions prevailing in the City of Mexico, it seems to be admirable, and it is difficult to conceive of a pavement which could be more satisfactory than the asphalt pavements of that city. After all, the real value of a pavement is not determined wholly by its wearing qualities. Its appearance is a most important consideration, and at present there is no material than can be kept so neat and so immaculately clean as asphalt under an efficient sytem of street cleaning. This is admirably illustrated in the City of Mexico; the speaker cannot recall ever having seen asphalt pavements in better condition or cleaner, than those laid on the principal streets. In walking to the Mineria, the speaker had a few scraps of paper in his hand, which he tried to dispose of; he had not the temerity, however, to throw them on the streets, which were perfectly clean, so he carried them into the building, where he disposed of them. The city government is to be congratulated upon its ability, not only to lay pavements of this kind well, but to keep them clean and maintain them very thoroughly. The officers in charge of street cleaning in northern cities might profitably visit the City of Mexico for an object lesson.

"The selection of the kind of pavement is, after all, what might be called a question of luxury, as has already been said; how good a suit of clothes can a man afford to wear?. Imagine the effect, on the rental value of an office building, of a clean pavement from which the dust will not be licked up and blown into the windows by every breath of wind, or of a pavement which is fairly noiseless. If distributed over that rent roll the money required to renew such a pavement, if necessary, every three or four years, would be trifling. It is this luxury for which the people of London are willing to pay; the pavement in general use there is not permanent; it has to be renewed every few years, but it is clean and quiet; and the people are willing to submit to the inconvenience of its frequent renewal.

"Block pavements are frequently urged and advertised because they can be repaired so readily; but the argument is fallacious. There is no pavement that can be repaired as readily as the modern artificial sheet asphalt pavement. If blocks are removed, they can never be laid as perfectly as they were originally, and when the true surface is gone, the blocks readily deteriorate. There is a disposition to relay the old blocks when they are not badly worn, but with the sheet asphalt pavement, the material put in is new and has the same life as the original pavement. By the time the pavement is 10 or 15 years old, with the many frequent openings which are unfortunately made, a very large part of it is relatively new. This constant reopening of pavements is annoying and most exasperating, and it is to be hoped that some way will be found to avoid it. As far as the pavements of the future are concerned, the speaker can see nothing to indicate that there will be anything new. As Mr. Tillson has said, almost every material has been tried—glass, straw, iron, wood—almost every elementary substance, and every mixture which ingenuity or imagination can suggest. It is quite probable that the pavement of the future will be quite similar to the pavement of to-day, and the speaker knows of nothing which equals, in its universal adaptability, the modern sheet asphalt pavement."

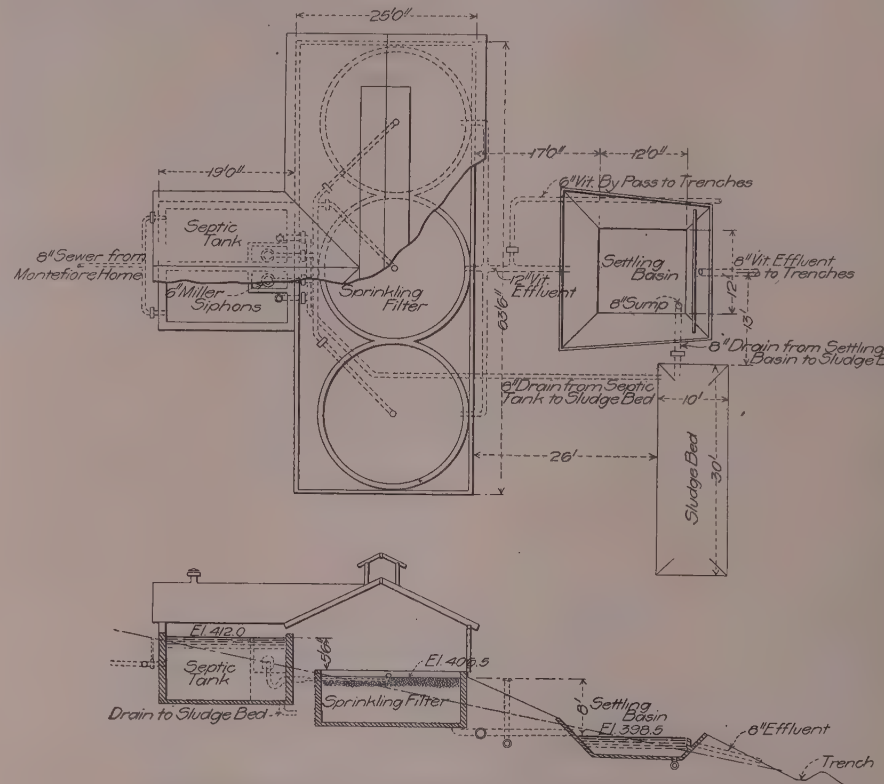
In the light of the preceding statement, it will readily be seen that the attacks upon asphalt pavements which are now so frequently heard are not based upon any rational consideration of the suitability of the form of construction employed in any particular instance; they are made without any regard to the environment to which the pavement is subjected.

A Gasolene-Electric Car.

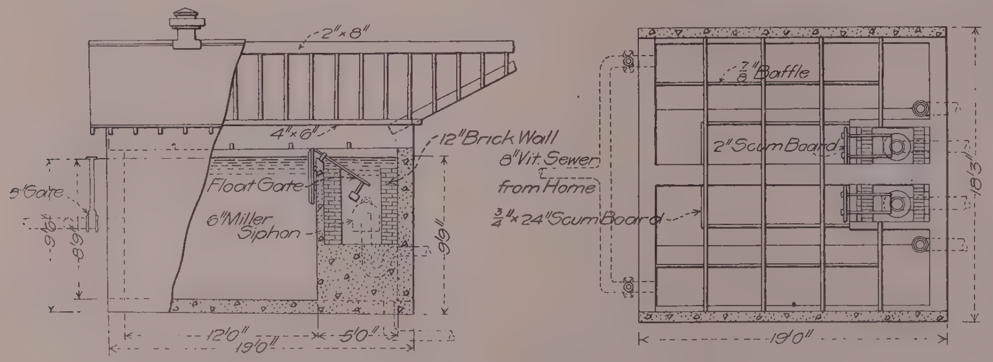
A gasolene-electric car, the second of the kind built for the Delaware & Hudson Co. by the General Electric Co., was recently run 78 miles over a route presenting a wide range of track and grade conditions. The car is 50 ft. over-all, and has a 9½-ft. engine compartment, a 6-ft. baggage compartment, 8-ft. smoker, and 18½-ft. passenger compartment, and is of much lighter construction than the previous car. It is of steel construction, with wood only in floors and interior finish, and weighs, with trucks, 31 tons. The engine has eight cylinders inclined at 45 deg. and operating on a four-throw crank. At a speed of 550 r. p. m., it has a rating of 100 h.p. It is started by a block mechanism for black-powder cartridges. The engine is direct connected to a 90-kw. eight-pole 250-volt direct-current generator of less than one-third the weight of a standard 90-kw. generator. It is separately excited for ease of control and has interpoles to assist the commutation of the excessive currents required for starting. There are two 60-h.-p. motors which are controlled by a special potential control made possible by the separate field excitation of the generator. On the trial run, the car with its full capacity of passengers attained a speed of 23 miles per hour on an up-grade of 1.3 per cent. The accelerations were said to be noticeably smooth and free from jerking. The heating of the car is accomplished by a novel method. Pipes are arranged under the seats and through them part of the exhaust gases are passed, the pipes having by-pass connections for controlling the heat as required.

Sewage Disposal Plant at the Montefiore Sanitarium.

A sewage disposal plant has recently been completed at Bedford Station, N. Y., to purify the sewage of the Montefiore County Sanitarium, which contains some features of interest. This institution has in general about 200 inmates and the daily water consumption is about 20,000 gal. The disposal plant is designed to handle a sewage flow of 30,000 gal. per day, which provides for an increase to 300 inmates. The new works, which replace an old and inadequate disposal plant, comprise a two-compartment covered septic tank with two dosing chambers, three covered sprinkling filters in which the filtering material is broken trap rock, a settling basin and a series of field trenches. The arrangement of the plant, with the exception of the trenches, is shown on an accompanying drawing.



Plan and Cross Section of Sewage Disposal Plant, Montefiore Sanitarium.



Septic Tank and Siphon, Montefiore Sanitarium.

The sewage is led by gravity from the buildings through about 980 ft. of 8-in. vitrified pipe to the septic tank in which the water level is at El. 412. The tank is built of concrete and is 18 ft. 3 in. x 19 ft. in plan outside. It is divided into two equal compartments by a vertical longitudinal wall; each compartment is 7 ft. 6 in. wide, 9 ft. deep below the water level and 17 ft. long inside, but this space also includes in each compartment a siphon chamber, as shown in the accompanying illustrations.

The main outfall sewer is divided outside the septic tank and an 8-in. branch leads to each tank compartment with a gate and gate box just outside the wall. The point of discharge into each compartment is near the outer side and about at mid-depth. Each compartment is sub-divided into three longitudinal divisions by ⅞-in. hemlock baffles, which cause the sewage to travel in each compartment approximately three times the length of the tank. The combined capacity of the two compartments is about 15,000 gal., or 12 hours' flow when the plant is operating at its nominal full capacity rate. The outside walls of the tank have a uniform thickness of 12 in., and are reinforced near both faces with ¾-in. square bars placed horizontally 6 to 12 in. center to center. The longitudinal partition wall is 15 in. thick and is similarly reinforced near each face. The tank floor is 6 in. thick and is without reinforcement.

The end wall of each siphon chamber forms a weir over which the sewage flows till the level of sewage in the chamber reaches a predetermined elevation, when the chamber is emptied by a 6-in. Miller automatic siphon. Scum boards of ¾-in. stuff extending completely across the inlet end of the outlet compartment of the septic tanks were installed to prevent the escape of floating solid matter into the siphon chamber. The capacity of these dosing chambers is such that under ordinary operating conditions their contents will be discharged onto the sprinkling filters at intervals varying from 10 to 20 min. The floor of each septic tank compartment slopes toward a small sludge sump at the outlet end. These sumps are connected to an 8-in. drain leading to a 10 x 30-ft. sludge bed just beyond the sprinkling filters.

After the plant had been put in operation, careful watch was kept on its operation and it was found that the siphons were working only indifferently well, showing a decided tendency to dribble at the end of the discharge period. Changes were accordingly made which have resulted in positive action satisfactory in all ways.

The first change was the installation of float gates in the siphon chambers to render the operation of the siphons positive in their action. These gates are 1 x 4½-in. strips extending completely across the width of the chamber, and are lined on the bottom and ends with a double strip of rubber to minimize leakage. They are each attached rigidly to two 1 x 3-in. arms which are secured to the scum board battens by padlock hinges. To the other end of these arms a 6 x 6 x 18-in. wooden float is attached by two 1 x 2-in. hangers 18-in. long. When the sewage in the septic tank has risen to 3 in. above the normal flow line, it begins to pour over the top of the float gate. As the quantity of sewage required to fill the chamber up to the level of the float is comparatively small, it is not long before the float begins to rise, thus lifting the gate and permitting the stored sewage to pour rapidly into the chamber and start the siphon. As the sewage is discharged onto the filters the level in the chamber accordingly drops, the float thereby shutting off the further feeding of the siphon chamber and insuring a positive break in the siphonic action.

The second change was made to decrease the capacity of the siphon chambers, and cause a more frequent discharge of the siphons. A 1½-ft. dry brick wall was built at each end of both chambers to within 9 in. of its top. These walls were then grouted in, as shown in the diagrams.

The discharge pipes of the two siphons are connected just beyond the end wall of the septic tank to a 6-in. header pipe from which a 4-in. wrought-iron distributing pipe leads to each of the three filters as shown on the drawings, suitable gate valves being provided for regulating or cutting off the flow in the various pipes. The three filter tanks are contiguous and are symmetrically arranged as regards the logitudinal axis of the septic tank with their centers on a line perpendicular to this axis. The septic tank and filters are all enclosed under a light frame structure with shingle roof, the main part of the building over the filters having a monitor and with adjustable shutters for ventilation.

Each filter is a cylindrical concrete tank 19 ft. 6 in. in diameter and about 6 ft. 3 in. deep measured from the top of the filtering material at El. 406.5 to the floor of the tank. The filtering material is crushed stone ranging in size from 1 in. to 2½ in. The distribution of sewage over each filter is effected by a sprinkler nozzle placed just above the top of the filtering material at the center of the tank. These nozzles are of the variety used at the Columbus, Ohio, sewage disposal plant; they were described in The Engineering Record of Dec. 30, 1905, and have been referred to in other numbers of this journal.

A 12-in. effluent pipe leads from the outlet end of the main underdrain of each filter to a connection with a 12-in. header pipe just outside the building, from which in turn a 12-in. pipe carries the effluent to the settling basin, the water level in which is at El. 398.5. This basin is 12 ft. square on the bottom and all its sides slope outward at an angle of about 45 deg. The depth of water in the basin is about 2½ ft., and its capacity is about 600 cu. ft. It is intended to collect any solid particles that may be in the filter effluent and is provided with an 8-in. vitrified drain through which such particles may be removed to the sludge bed. A concrete weir wall extends clear across the outlet end of the basin and over this the effluent flows to an 8-in. vitrified drain leading to the trenches. A 6-in. bypass pipe is provided so that the settling basin can be cut out when cleaning or repairs are necessary.

The open trenches occupy a sidehill area of about 300 x 500 ft., the longer dimension being measured along the sidehill. The slope of the hill is fairly uniform, the fall being in general about 5 ft. in 40 ft. There are about ten parallel ditches, the top one being nearly coincident with the contour 395 and the bottom one being just above contour 365. The trenches are about 18 in. deep and about 1 ft. wide on the bottom with flaring sides. Below the lowest trench is a catch-drain trench, with its top about at El. 360. This trench is 3 ft. deep with flaring sides, and is filled with crushed stone or gravel. Its bottom and downhill side are lined with a 3-in. slab of concrete, and along the bottom of the trench on the concrete is laid a 6-in. vitrified pipe drain with open joints. This has a fall of 1 ft. in 100 ft., and leads to an outlet where the effluent is discharged into a water course tributary to Croton Lake. An open gutter extends along the top of the slope above the trenches to carry off surface water which would otherwise run down into the trenches.

A mechanical analysis of a sample of soil from the west end of the trench field showed that the effective size was 0.10 mm. and the uniformity coefficient was 6.40; a sample from the east end of the field had an effective size of 0.125 mm., and its uniformity coefficient was 5.27. This material while it contains considerable quantity of fine clay and loam is considered by the engineers to be capable of giving satisfactory results under the conditions described.

The plant was designed by Messrs. Hering & Fuller, New York.

Sewage Sprinklers in Operation at Montefiore Sanitarium.

Rails for the Pennsylvania R. R.

The Pennsylvania Railroad Co. placed definite orders on Feb. 6 with steel manufacturers for 55,000 tons of rails to be delivered during 1908. These, in addition to 30,000 tons left over from 1907, will give the company 85,000 tons for use this year. These rails will be rolled under entirely new specifications. In view of the increasing severity of road service and the recognized necessity for developing an improved steel rail, the Pennsylvania R. R. has for some months been conducting an exhaustive examination of the entire art and practice of rail manufacture. A committee of experts—representing not only the railroad, but two of the important steel manufacturers—was appointed by the Pennsylvania System last summer to make a special study of the subject. The series of experiments undertaken were probably unprecedented in their completeness and in the importance of the scientific data which they supplied. The rail sections are believed to be a distinct improvement upon those hitherto in use on the Pennsylvania System.

Most important of the features of the new specifications is the placing more upon the manufacturer the responsibility for the character of the rail produced. The company recognizes that it is merely a purchaser, not a manufacturer. Considerable latitude is, therefore, to be allowed in the methods of manufacture utilized, so long as the result is a sound rail. The company has devised tests of a character so exacting that it is made very much to the interest of the manufacturers to discard all material of the soundness of which there is any doubt.

No specification, for example, is made as to the amount which shall be sheared from the end of the bloom formed from the top of the ingot. The problem of a proper discard has been discussed very freely by the different societies which have been considering rail specifications. Various percentages have been proposed, a discard of 25 per cent. having the greatest number of advocates. The Pennsylvania R. R. feels, however, that, in the present state of the art, at any rate, the responsibility for a proper discard should be left with the manufacturer.

The new specifications also provide that rails shall be free from "injurious" mechanical defects and flaws. This differs from the old specifications in that no attempt has been made to describe the particular defects or flaws that will cause the rejection of rails. It is not considered wise to attempt to classify in the specifications the relative importance of defects, but it is specified that no rails will be accepted that contain defects or flaws which in any way impair their strength.

The methods to be used in testing the new rails are very elaborate and comprehensive. To still further strengthen the practice of the company and to insure whatever future changes are made shall be based upon accurate data, a system has been devised whereby the history of all rails purchased by the company shall be fully recorded. In order that for this purpose it may be possible to identify the part of the ingot from which particular rails were made, the new specifications require, in addition to the usual marking, that a letter shall be stamped on each rail to indicate its position in the ingot.

To compile and consider the company's experience with rails, a special committee is to keep continually in thorough touch with the art, and is expected to supply the company with data that will enable it to secure the best rails which, at the time of any order, it is possible to manufacture.

In placing its orders, the Pennsylvania Railroad invited the steel manufacturers to undertake to fill part of the allotment with rails made by the open-hearth process. It is desired to ascertain more clearly the actual differences in service between the open-hearth and the Bessemer product.

Rating House Heating Boilers.

As a part of the topical discussion on testing and rating house-heating boilers at the recent meeting of the American Society of Heating and Ventilating Engineers, the following methods were proposed by Prof. Wm. Kent, of Syracuse University. These suggestions had been presented at a previous meeting of the Society, but have been revised to the present form.

The testing of the evaporating power and the economy of small-sized boilers is more difficult than that of large steam boilers for the reason that the small quantity of coal burned in a day makes it impossible to procure a uniform condition of the coal on the grate throughout the test, and large errors are apt to be made in the circulation on account of the difference of conditions at the beginning and end of a test. The following is suggested as a method of test which will avoid these errors:

(a) Measure the grate-surface and weigh out an amount of coal equal to 30, 40 or 50 lb. per sq. ft. of grate, according to the type A, B or C, or the ratio of heating to grate surfaces.

(b) Disconnect the steam-pipe, so that the steam may be wasted at atmospheric pressure. Fill the boiler with cold water to a marked level, and take the weight of this water and its temperature.

(c) Start a brisk fire with plenty of wood, so as to cause the coal to ignite rapidly; feed the coal as needed, and gradually increase the thickness of the bed of coal as it burns brightly on top, getting the fire-pot full as the last of the coal is fired. Then burn away all the coal until it ceases to make steam, when the test may be considered as at an end.

(d) Record the temperature of the gases of combustion in the flue every half hour.

(e) Periodically, as needed, feed cold water, which has been weighed, to bring the water level to the original mark. Record the time and the weight.

Calculations:

Total water fed to the boiler, including original cold water, lb. × (212° — original cold-water temperature) = ...B.t.u.
Water apparently evaporated, lb. × 966 = ...B.t.u.
Add correction for increased bulk of hot water:
Original water, lbs. 966 (62.3 — 59.8) ÷ 62.3 = B.t.u.

Total = ...B.t.u.

Divide by 966 to obtain equivalent water evaporation from and at 212° Fahr.

Divide by the number of pounds of coal to obtain equivalent water per pound of coal.

The last result may be considerably less than 10 lb. on account of imperfect combustion at the beginning of the test, excessive air-supply, when the coal bed is thin in the latter half of the test, and loss by radiation, but the results will be fairly comparable with other results from boilers of the same size and run under the same conditions. The records of water fed and of temperature of gases should be plotted, with time as the base, for comparison with other tests.

The rating of a steam boiler for house-heating may be based upon one or more of several data. 1st, square feet of grate surface; 2d, square feet of heating surface; 3d, coal burning capacity; 4th, steam making capacity; 5th, square feet of steam radiating surface, including mains, that it will supply. In establishing such a rating, the following considerations should be taken into account:

1. One square foot of cast-iron radiator surface will give off about 250 B. t. u. per hour under ordinary conditions of temperature of steam at 212° and temperature of room at 70°.

2. One pound of good anthracite or semi-bituminous coal under the best conditions of air-supply, in a boiler properly proportioned, will transmit about 10,000 B. t. u. to the boiler.

3. In order to obtain this economical result from the coal the boiler should be driven at a rate not greatly exceeding 2 lb. of water evaporated from and at 212° per square foot of heating-surface per hour, corresponding to a heat transmission of 2 × 966 = 1,932, or, say, approximately 2,000 B. t. u. per hour per square foot of heating-surface.

4. A satisfactory boiler or furnace for house-heating should not require coal to be fed oftener than once in 8 hours; this requires a rate of burning of only 3 to 5 lb. of coal per square foot of grate per hour.

5. For commercial and constructive reasons, it is not convenient to establish a fixed ratio of heating to grate-surface for all sizes of boilers. The grate-surface is limited by the available area in which it may be placed, but on a given grate more heating-surface may be piled in one form of boiler than in another, and in boilers of one general form one boiler may be built higher than another, obtaining thus a greater amount of heating-surface.

6. The rate of burning coal and the ratio of heating to grate-surface, both being variable, the coal-burning rate and the ratio may be so related to each other as to establish condition 3, viz., a rate of evaporation of 2 lb. of water from and at 212° per square foot of heating-surface per hour.

These general considerations lead to the following calculations:

1 lb. of coal, 10,000 B.t.u. utilized in the boiler, will supply 10,000 ÷ 250 = 40 sq. ft. radiating-surface.
1 lb. of coal, 10,000 B.t.u. utilized in the boiler, will require 10,000 ÷ 2,000 = 5 sq. ft. heating-surface.
1 sq. ft. of boiler heating-surface will supply 2,000 ÷ 250 or 40 ÷ 5 = 8 sq. ft. radiating-surface.

Properties of Boilers.

	Low boiler.	Medium.	High boiler.
1 sq. ft. of grate-surface should burn	3	4	5 lb. coal per hour
1 sq. ft. of grate-surface should develop	30,000	40,000	50,000 B.t.u. per hour
1 sq. ft. of grate-surface will require	15	20	25 sq. ft. heating-surface
1 sq. ft. of grate-surface will supply	120	160	200 sq. ft. radiating-surface
Type of boiler, depending on ratio heating-surface ÷ grate-surface	A.	B.	C.

Table of Ratings.

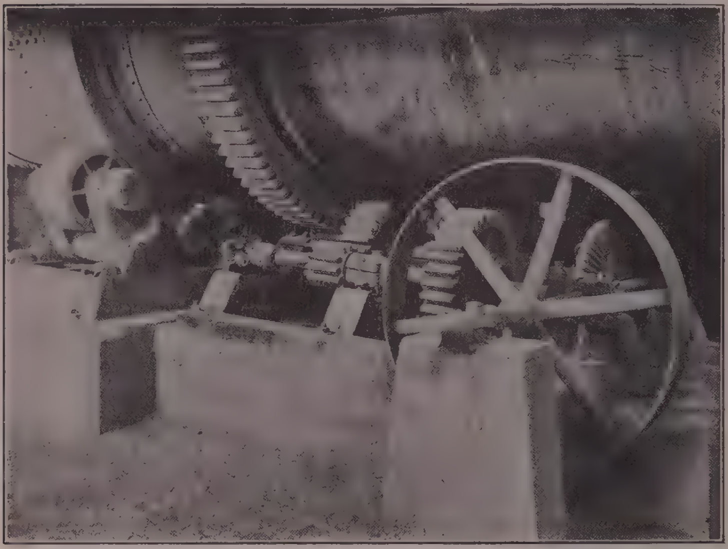
Type and No.	Grate, sq. ft.	Heating-surface, sq. ft.	Coal per hour, lb.	Water evaporated per hour, lb.	Radiating-surface supplied, sq. ft.
A 1......	1	15	3	30	120
A 2......	2	30	6	60	240
A 3......	3	45	9	90	360
A 4......	4	60	12	120	480
A 5......	5	75	15	150	600
B 4......	4	80	16	160	640
B 5......	5	100	20	200	800
B 6......	6	120	24	240	960
B 7......	7	140	28	280	1,120
B 8......	8	160	32	320	1,280
C 6......	6	150	30	300	1,200
C 7......	7	175	35	350	1,400
C 8......	8	200	40	400	1,600
C 10......	10	250	50	500	2,000
C 12......	12	300	60	600	2,400
C 14......	14	350	70	700	2,800
C 16......	16	400	80	800	3,200

The table is based on the utilization in the boiler of 10,000 B.t.u. per pound of good coal. For poorer coal the same figures will hold good except the pounds coal burned per hour, which should be increased in the ratio of the B.t.u. of the good to that of the poor coal. Thus for coal from which 8,000 B.t.u. can be utilized the coal burned per hour will be 25 per cent. greater.

Height.	G Grate.	H Heating-surface.	R Radiating-surface.	$\frac{H}{G}$	$\frac{R}{G}$	$\frac{R}{H}$	B.t.u. per hour. = R × 250.	$\frac{\text{B.t.u.}}{\text{H.}}$	Coal per hour per sq. ft. of grate.*
Low.........	2.1	45	210	21.5	100	4.7	52,500	1167	2.5
	4.7	90	600	19.1	128	6.7	150,000	1667	3.2
Medium......	4.2	103	600	24.5	143	5.8	150,000	1456	3.6
	8.2	195	1500	23.8	183	7.7	375,000	1923	4.6
High.........	6.7	210	1200	31.3	179	5.7	300,000	1476	4.5
	14.7	420	3300	28.6	225	7.9	825,000	1964	5.6

*Equals B.t.u. per hour ÷ 10,000 G.

For comparison with the tables entitled "Properties of Boilers" and "Table of Ratings" the larger table was arranged and calculated from the figures in the catalogue of a prominent maker of cast-iron boilers.


Details of Drive of Kiln.

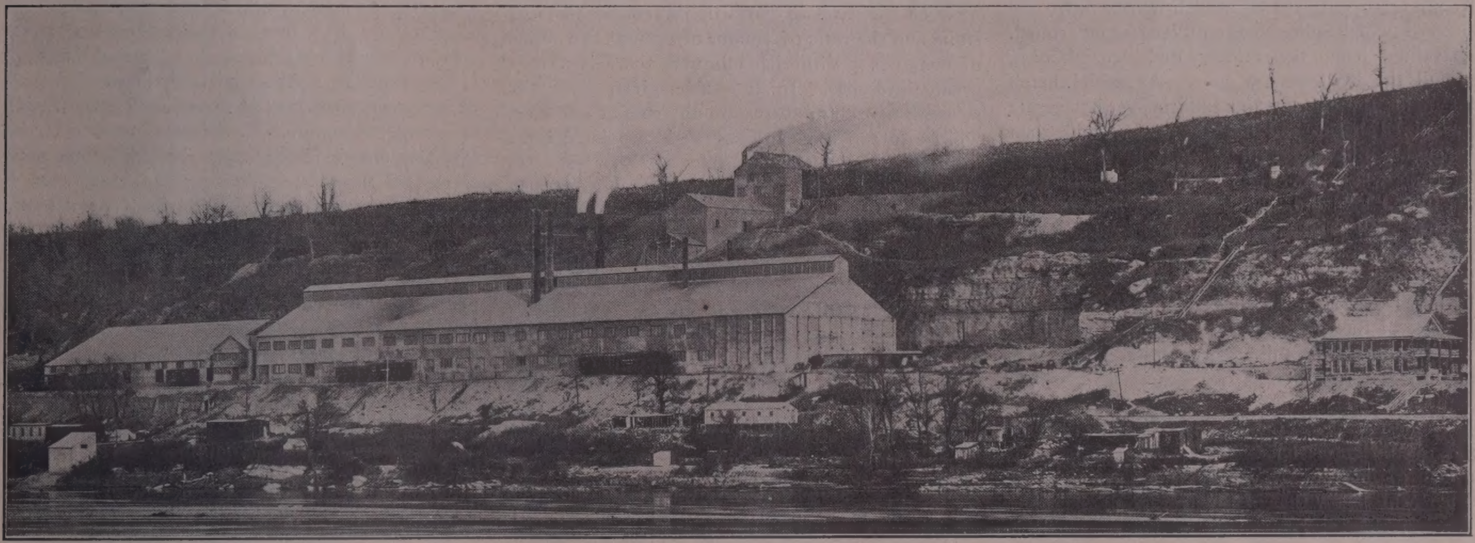
General View of Kiln Room.

The Electric Drive in a New Cement Mill.

By A. Bickel.

This article, while intended to give a description of the construction, equipment and operation of the new plant of the Kansas City Portland Cement Co., will not enter into the details of cement manufacture, for this phase of the subject has been dealt with thoroughly in previous issues. The plant of the company is located eleven miles northeast of Kansas City, and is situated on the Missouri River bluffs overlooking the river and valley.

The quarries from which are obtained the raw materials, are located 200 ft. above the river, extend a mile either side of the crusher building and are served by an industrial railway equipped with automatic side-dump cars and a 20-ton oil burning locomotive. The main track of the industrial railway passes directly through the headhouse of the crusher building and the cars are automatically dumped directly into the hoppers of the crushers. The limestone crusher is driven direct by a 100-h.-p. constant-speed induction motor. The shale pulverizer is driven direct by a 30-h.-p. constant-speed induction motor. The starting and protecting devices are located adcent to each motor, and each motor is, therefore, individually and independently controlled and protected, and always under the eye of the operator when starting or stopping.



General View of Mill of the Kansas City Portland Cement Company.

The materials from the crusher and pulverizer are discharged directly into individual rotary dryers, each 6 ft. in diameter by 60 ft. in length, and the drying process is accomplished by combustion of fuel oil within the dryers. For economical operation it is necessary that both dryers be in operation at the same time and they are, therefore, driven collectively by a 30-h.-p. constant-speed induction motor.

The dryers discharge into individual storage bins, each having a capacity sufficient for three days' operation. Working in connection with these storage bins is an automatic hopper scale charging car, operated by a power haul which automatically receives and mixes materials from each of the bins. After being mixed thoroughly and in the proper proportions, the material is automatically dumped into a gravity chute and delivered to the raw mill some 40 ft. below this point of operation.

The raw mill is equipped with large steel bins which receive the raw materials from the gravity chute. The bins are arranged to discharge automatically the raw material directly into hammer mills, where the process of pulverizing and mixing is carried to a further degree. The hammer mill discharges directly into a bin equipped with a conveyor, which automatically elevates and discharges the pulverized material into bins located in an advantageous position for feeding the tube mills.

The raw material passes from the last-named bins to tube mills 5 ft. in diameter by 22 ft. in length, where it is further pulverized, mixed and prepared for entrance to the kilns. The raw material is carried and fed to the upper end of the kilns by a screw conveyor.

The plant is equipped with four rotary kilns, each 8 ft. in diameter by 125 ft. in length, each having a capacity of 500 to 750 bbl. per day. Each kiln is driven directly by a variable-speed induction motor, with a speed range from maximum to 50 per cent. at constant torque. The motors and drive are located approximately midway of each kiln, while the controllers and protective apparatus are located directly in front of each kiln, thereby simplifying at a glance, for the operator, the relation of speed to feed and temperature.

These kilns are unique in the fact that they are the largest rotary steel-shell kilns in operation and contain many features pertaining to drive and method of burning clinker. They were specially designed, constructed and erected under special supervision of the engineers for the plant and have proved in operation a great deal more than was guaranteed or expected of them.

The kilns discharge the clinker at the lower end into a pit equipped with a bucket elevator which handles and discharges the clinker directly into 6 x 60-ft. rotary coolers, each driven by constant-speed induction motors.

The clinker, after passing through the coolers, is transported by an industrial tramway to either the clinker storage bin or directly to the finishing mill, where it is discharged into large steel hopper bins. The hopper bins feed directly into the Griffin mills, where the preliminary grinding is accomplished and the product discharged into a pit equipped with a conveyor which transports the material to bins located so as to advantageously feed the finishing tube mills. The final grinding and mixing is accomplished by tube mills 5 ft. in diameter by 22 ft. in length. These mills discharge directly into a conveyor, which transports the finished material to the stockhouse, where it is stored ready for sacking and shipment.

The stockhouse is equipped with portable automatic weighing and sacking machines, each driven by a constant-speed induction motor. Between the stockhouse and main mill is located a machine shop, equipped with tools to make all necessary repairs for the entire mill. A portion of the shop equipment consists of a traveling crane, steam hammer, lathes, shapers, boring mill, pipe machine, keyseating machine, planers and grinding machinery. The entire shop is driven by a constant-speed induction motor.

The power plant is located in the center of the main mill building and is divided into sections, each driving half of the mill. The boiler room equipment consists of a battery of water-tube boilers equipped with economizers and oil-burning apparatus.

The engine room equipment consists of two 1,000-h.-p. cross-compound condensing Corliss engines, transmitting power by two rope drives; two tandem-compound four-valve engines direct-connected each to a 200-kw., 440-volt, three-phase 60-cycle revolving-field, alternating-current generator; one 200-kw. 440-volt three-phase 60-cycle belt-driven alternating-current generator, and auxiliary apparatus, such as surface condensers, exciters and switchboard.

The water for condenser and boiler feed purposes is obtained from the Missouri River by means of three Worthington single-stage turbine pumps, direct-connected to three constant-speed induction motors. The reinforced concrete pumphouse is located on the river bank about 200 ft. from the power house and the water is delivered by means of a pipe laid in an accessible tunnel.

Those portions of the plant subjected to extremely severe service are equipped in duplicate and a break-down in any one of these departments will not discontinue or handicap operation. To further insure against operating interruptions, the steel bins supplying material to all grinding machinery are of sufficient capacity to supply the mill for twelve hours. The reinforced concrete clinker storage bins are of sufficient capacity for 5,000 bbl. The reinforced concrete cement storage room has a capacity for 50,000 bbl. of finished product. The entire plant is of fireproof construction.

The mill was placed in operation some five months ago and has far exceeded the guarantees of the engineers and the expectations of the owners in the quality and quantity of product and low cost of operation. The entire plant was designed and constructed by the Freeborn Engineering & Construction Co., Kansas City, Mo.

THE PIG IRON PRODUCTION in the United States in 1907 was 25,781,361 gross tons, according to the American Iron and Steel Association. This amount was 1.9 per cent. greater than that of 1906, and would have been still larger but for a decrease of production in the last part of the year, which continued into January, 1908, during which month the output was below that of any other month since January, 1904. Canada produced 581,146 tons in 1907.

Proportions of Concrete and Methods of Mixing.

A paper read at the Buffalo Convention, National Association of Cement Users, January, 1908, by L. C. Wason.

The first part of this paper is devoted to the proportions and strength of concrete, and is of interest to the engineer, while the latter part is devoted to equipment, methods and cost, and appeals especially to the contractor.

The necessity of thorough mixing has been universally known for many years. The loss of strength from poor mixing is not perhaps so well known in figures. There were some private tests made at the Watertown Arsenal about eight years ago in which the writer was interested, which throw some light upon improper mixing. On a large job a certain type of mixer was disapproved by the supervising engineer, who insisted upon a comparative test of machine and hand-mixed concrete. All concrete was made with proportions of 1:3:5, the broken stone ranging from ½ to 2½ in., and was moulded into one-foot cubes. A full size batch was first made with machine without any previous dry mixing of the aggregates. As the material was dumped from the mixer a cone was allowed to form, down the sides of which quite a quantity of stone rolled, separating from the mortar and accumulating around the base of the cone. A second batch was made, the cement and sand being thoroughly dry mixed before adding the stone, and then thoroughly mixed together when in the mixer. No cone was allowed to form. A third batch was mixed by hand, being turned five times, the engineer with a hoe throwing into the mass stones which became accidentally separated from it. In filling the moulds the engineer insisted that from the first batch, stone be shovelled up from around the base of the cone. The rest of the batch which remained properly mixed was filled into other moulds, four cubes and two beams being made from each batch.

The first cube averaged only 2⅛ lb., or about 2 per cent. lighter than the other three cubes, due to lack of mortar. Nevertheless it gave a result 28 per cent. below that of the average of the other three, the figures being 3,081 lb. per square inch as against 4,263 lb. per square inch, the average of the other three. Age of all specimens was 90 days. The average of the four cubes which were dry mixed before mixing in the machine was 4,123 lb. The hand-mixed specimens averaged 3,187 lb. It will be seen that there is an advantage in machine-mixed concrete over that made by hand of 25¼ per cent., and that that which was not dry mixed before putting into the machine gave 3⅛ per cent. greater strength than that which was first dry mixed. The machine used in this case was the Portable Gravity concrete mixer. It is safe to assume that these specimens were more carefully made than under ordinary commercial conditions, which they tried to reproduce, and the marked weakness of the specimen which lacked but a small amount of mortar is very significant. The weakness is doubtless due to the voids in the material reducing the cross sectional area.

Ten years ago another series of experiments was conducted by the writer at the Watertown Arsenal, giving the relative merits of machine and hand-mixed concrete and the strength of various mixtures. A cylindrical drum batch mixer was used. These were specimens one foot square and varying from 6 to 14 ft. in length. They were all made in midwinter in an open lumber shed and remained in the open air until tested, which accounts for the low ultimate strength.

The modulus of elasticity of the hand-mixed specimens with proportions of 1:3:6 and average age of 43 days at a stress of 700 lb. per square inch was 2,500,000, the machine-mixed, 2,870,000, an increase of 12½ per cent. in the modulus. The ultimate strength of the hand-mixed was 921 lb., the machine-mixed, 1,111 lb., an increase in the ultimate strength of 17 per cent., due to machine mixing. The hand-mixed specimens in this case were somewhat better than commercial conditions, because in order to fill the moulds the concrete was handled several times more than would be necessary in placing ordinary work. Each handling was equivalent to a mixing.

It will be seen, therefore, that there is a marked improvement in strength, due to machine mixing, and as the machine is positive we can be assured of obtaining this concrete uniform, whereas with hand work it is likely to be anything but uniform, while a little carelessness makes a big difference in the final strength.

Another series of specimens were made one foot square, six feet long, machine-mixed, identical in every way except the amount of cement used. There were two specimens each of the following proportions: 1:3:6, 1:4:8, 1:5:10, 1:6:12, 1:7:13. The results of each pair were averaged. While these tests are not extensive enough to be conclusive they indicate that the strength is directly proportional to the amount of cement used. It is important to note the difference between the ratio of parts of cement to parts of stone and the ratio of volume of cement to volume of concrete. With rich mixtures there is a very great difference. In the table given later the strength of rich mixtures are all from actual tests, while a few of the lean ones are interpolated from a diagram on which the results of these last tests were plotted. The lean mixtures most nearly agreed with the average line. If a similar diagram is made for the rich mixtures in the table it will be noted they are also proportional in strength to the amount of cement used. The results can also be expressed mathematically.

Taking the common formula for a straight line, $y = mx + b$, where y = volume of cement ÷ volume of concrete, x = ultimate strength of concrete in pounds per square inch, and m = slope of line whose intercept on the y axis is b. From the diagram of the results of these tests we obtain

$$y = .00011x + .03$$

$$x = 9{,}091y + 273$$

During the construction of the Boston subway the engineers got better results from briquettes made from mortar taken from hand-mixed concrete on the job than from that mixed in the laboratory, which would indicate that if laboratory tests are satisfactory, work properly done by hand on the job is bound to be. During the past season, when there has been such great activity in all lines of industry so that there has been a great demand for labor, it has been difficult to keep laborers on jobs where concrete was hand-mixed on account of this class of work being harder than other forms of concrete work. At the same time the laborers appeared to be more ignorant than of old as to how to mix by hand. Below is an exact copy of table used for many years in the writer's practice of proportions and corresponding strength for concrete as taken from actual tests from reliable sources.

The costs in the table are based on the followin constants:

Cement (3.8 cu. ft.) on job, per bbl., net..........	$1.75
Broken stone (21 cu. ft. = 1 ton), per ton..........	1.50
Sand, per cubic yard..............................	1.20
Gravel, per cubic yard............................	1.15
Labor, per cubic yard.............................	1.62

In the selection of sand care should be used to avoid that which is fine and not sharp. The difference in strength due to these qualities alone in some tests of the writer's on sand that was used in foundations amounted to a loss of 52 per cent. from standard sand. Dirt should also be avoided. There has been some controversy as to how much can be permitted, but the writer believes that the ordinary test which is performed on the work of throwing a handful into a glass of water is sufficiently reliable for all cases. When the water is badly muddied and remains clouded for a considerable time the sand should be washed or rejected.

Table of Properties of Concrete.

Proportions.	Vol. in place cu. ft.	Bbl. of cement per cu. yd.	Cost per cu. ft. broken stone concrete.	Cost per cu. ft. gravel concrete.	Ult. compr. strength broken stone concrete, 1 mo. old, per sq. in.	Av. ult. compr. strength per sq. in. of brickwork.
1: ½ :1	6.8	3.97	$.37	$.34	5340	...
1: 1:2	9.7	2.79	.314	.274	4000	...
1:1½ :3	12.6	2.14	.283(*a*)	.237	3200	835
1: 2:4	15.6	1.73	.264	.214	2700	...
1:2½ :5	19.0	1.42	.246	.195	2300	...
1: 3:6	22.8	1.18	.23	.179	2009	...
1:3½ :7	26.6	1.02	.219(*b*)	.169	1785	486
1: 4:8	30.4	.89	.210	.160	1625	...
1:4½ :9	34.2	.79	.205	.154	1500	...
1: 5:10	38.0	.71	.200	.149	1400	...
1:5½ :11	41.8	.65	.195(*c*)	.145	1320	347
1: 6:12	45.6	.59	.192	.141	1250	...

(*a*) First-class brickwork in cement mortar, 44 cents per cubic foot. (*b*) Good brickwork in cement, 35 cents. (*c*) Ordinary brickwork, 26 cents.

There is little difference obtained in results of broken stone or gravel. By actual test the writer has found that a broken stone having a rough surface with angular fractures will give an increase in strength over a rough bank gravel of about 15 per cent. in most cases. In some, however, the gravel has given the greatest strength. If the stone has a glossy surface such as is found with some trap rocks the gravel will always give the greatest strength. In the first instance, if the specifications required 1:3:6 broken stone concrete and there is a difference in cost between broken stone and gravel screenings of 2 cents per cubic foot it will be cheaper to use a mixture of 1:2½:5 with gravel and still obtain an equal strength with the broken stone. The writer makes the rule never to allow the size of stone in its greatest dimension to be more than half the thickness of the work into which the concrete is to be placed. In large size work, very much larger stone can be used than is ordinarily done with very good results, the only limitation being that of convenience in handling. In regard to placing, it is much easier to obtain dense concrete, that is, without voids, using gravel than using broken stone, as angular pieces will sometimes arch together allowing a void to form underneath. Therefore, for water-tight work gravel is to be preferred every time. For nearly all classes of work the best results will be obtained by using such an amount of water that the concrete when placed will just barely quake, but is not sufficiently soft to flow.

The leanest mixture the writer ever uses is 1:4:8. In heavy bridge abutments where mass rather than great strength is wanted, with thorough mixing and careful placing still leaner mixtures might be used with safety. By reference to the table it will be seen that only one cent per cubic foot will be saved by using a mixture of 1:5:10, and the owner ought to pay this difference as insurance against the carelessness which is apt to occur on this class of work. In building construction where no restrictions exist the writer's standard mixture is 1:3:6 for every part of structure. In 14 years of practice this has had some severe tests without failure. In one floor built 11 years ago and which has been frequently overloaded ever since, there have been a number of minor failures because the foreman, contrary to orders, mixed one floor 1:3½:7. This would appear then to be the limit of leanness. Mixtures of 1:2½:5 and 1:2:4 are often used, but are unnecessary in ordinary cases. Where a floor or column will be loaded in two to three weeks or is subject to vibration the richer mixture is desirable. A mixture richer than 1:2:4 is never necessary except in heavily loaded columns whose size is limited. Cement is the cheapest and easiest form of reinforcement. The writer has used in columns one part of cement to one part of graded stone without any sand for a working load of 1,200 lbs. per square inch. When this is done care must be used to continue this mixture through the thickness of floor, which will have a leaner mix.

Mixers are of two general types, the continuous and the batch. The continuous can be divided into those with and those without power. Without power the principal machines are the Portable Gravity and the Haynes mixer, which is a series of conical hoppers supported one above another. The principle of both of these is identical; a concave inclined surface with pins inclined relatively to this surface of the machine. Those with power are of the trough type and have various means for mixing, such as screw, paddle blades or revolving trough or drum with blades attached to side. The difficulty of good work with all this class of mixers is in combining materials before feeding into the machine. If they are not properly combined in the right proportions before feeding it cannot be done afterwards. There are various types of automatic feed to overcome this trouble, but they are not all positive and require constant attention. This type of machine is not much used now, due chiefly to this uncertainty and in part because they are not as economical to operate as a good batch mixer.

Batch mixers are almost universally used because their mixing is positive. They can be obtained in the form of cubes, cylinders and double cones. All give good results because all material in each charge is thoroughly mixed together, the difference in operation of the various machines being in the case of discharging and the wear and tear of the machine parts. The writer has used the Chicago cube, the Ransome and McKelvey cylindrical and the Smith double cone machines, and prefers the latter to any other because of its very quick and clean discharge and because the wear and tear is small. With the batch mixer it is entirely unnecessary to dry mix before wet mixing. It is also somewhat difficult because the water remaining from one batch will interfere with the dry mixing of the next. The best method to follow when the whole batch is not dumped into the machine at once from a measure is to add water first, then stone; these scour out the mixer so that it always runs clean, then, cement and sand last.

The question is sometimes asked when to use a mixer. The answer is when the cost of setting up, taking down and transportation equals the difference in cost of mixing by hand or machine. It has been the writer's experience that under ordinary conditions concrete can be measured and mixed by hand for $1.30 per cubic yard and by machine for $.85 per cubic yard for the simplest method of setting up. The difference between these, $.45, times the number of yards to be mixed, will give the saving to be used in paying the general expenses of setting up a mixer, which for teaming a distance of three or four miles, setting up, dismantling and returning, together with allowance for wear and tear, amounts to $70. The cost of operating is included in the above cost of mixing. It will thus be seen that a job using 155 cu. yds. will be as cheap machine-mixed as by hand, and of course any larger job should invariably be mixed by machine. The size to use should be determined by the size of the job and the amount which must be placed in one day. It is always best, however, to err on the safe side by having too large a machine than too small a one. Have one that is capable of mixing the day's work in three quarters of a working day, allowing three minutes for mixing a batch and assuming a barrel of cement to contain 3.8 cu. ft., which equals 100 lbs. per cubic foot, and is now becoming quite general.

The greatest problem of operating a mixer is that of feeding and removing concrete. A mixer of the proper size will always mix faster than this can be accomplished. The simplest way of feeding, which is suitable for small jobs, is to build a wheelbarrow run to the feeding hopper and dump directly in. The hoppers which are attached to machines of some makes, which lie on the ground and are filled by wheelbarrows and then lifted by the power that drives the mixer and dump into the machine, are very convenient and economical ways for handling concrete on small jobs, and reduce the cost somewhat from the first method named. For large installations more economical methods should be obtained. Local conditions have such an influence upon the arrangement of plant that no general rule can be given.

On a job the writer had the past year where over 125 yards had to be handled every day and where there was no room for storage on the ground, local conditions determined the following method. The job was situated between two buildings. There was a canal between them in which the concrete was placed. On one side there was just room enough for a railroad track, on the other there was a width of 25 ft. To handle materials elevated bins holding about 50 tons of stone and 30 tons of sand were built high enough so that the aggregates were drawn through spouts into a measuring box, stone in front, sand behind, cement on top. This was pivoted to tilt and dump directly into mixer, which in turn was raised high enough for tram cars on rails to run underneath and receive the discharge, a four bag batch at a time. Two derricks were erected on the edge of the canal with booms long enough to reach across. Skips were set into the freight cars, filled by hand and swung by the derricks and dumped into the elevated bins. This method proved very satisfactory and economical. Fifteen freight cars were unloaded daily. After one was unloaded it was pulled ahead by block and tackle by the hoisting engine and replaced by another. The derricks commanded three cars at a time. By this means the cost of unloading cars and measuring and mixing was $.338 per cubic yard, and the cost of the installation, maintenance, dismantling and rental, which handled 3,410 yards, was $1,571.93, or $.461 per cubic yard.

In isolated places where crushers have had to be erected we have erected elevated bins with bucket elevator and rotary screen high enough to draw materials into the measuring hopper and discharge directly into the mixer, and found the cost of mixing to be $.346 per cubic yard and the installation to vary from $1.98 per yard for a small volume of concrete to $.61 per yard for a large volume. Where conditions require cars to be unloaded onto the ground or where teams can dump close to the mixer a very convenient way is to set a measuring hopper flush with the surface of the ground, dig a hole into which the mixer is set so that the hopper dumps directly into it and set the elevator which handles the material into a building low enough to receive the discharge from the mixer. This set-up is inconvenient if the concrete is not to be lifted to a considerable height, as in building work. For feeding a mixer in this way the two-wheel barrows, holding 6 cu. ft., will be found very convenient and economical to use, because they handle a considerable volume at one time.

The above methods, though briefly described, may throw some light upon handling concrete, the economy of which depends upon handling it in large masses without the requirement of much labor. It is possible, however, as the writer has learned by experience, to spend so much in the installation of an economical mechanical plant that the incidental costs of installation offset the saving in the cost of the mixing of a comparatively small volume of concrete over the cost of a very simple set-up, with higher labor cost of operating. Therefore trained judgment is always the best guide in the long run.

Book Notes.

The success of the "Mechanical World Pocket Diary" has led the same publishers to issue a small "Mechanical World Electrical Pocket-Book" after the same general plan. It is a diary for 1908, combined with data and tables relating to the mechanical side of electrical engineering, omitting telegraphy, telephony, electric traction and the details of dynamo design. The information is very much condensed and elementary, but will probably be found of value by those who do not need the more detailed discussions given in larger books or who wish a reference book giving what may be called practical notes rather than formulas and rules for the design of machinery. One section likely to prove generally valuable is an analysis of the nature and remedy for various troubles of dynamos and motors. (Emmott & Co., 65 King St., Manchester, Eng., sixpence.)

The director of the New York Public Library, Dr. J. S. Billings, has had prepared a useful "List of Works in the New York Public Library Relating to Hydraulic Engineering," which forms a pamphlet of 102 pages. The notes are classified under the following headings: Bibliography, History, General Works, Aqueducts, Breakwaters and Jetties, Canals, Cement and Mortar, Culverts, Dams and Reservoirs, Docks and Walls, Drainage, Dredges, Hydraulic Elevators, Harbors, Irrigation, Hydraulic Laboratories, Levees and Dykes, Locks, Water Meters, Pipes and Conduits, Hydraulic Presses, Pumps, Rivers, Towers and Stand Pipes, Water Power and Water Wheels, Water Supply and Wells. Many of the references are to books and pamphlets which are very scarce, and the list will undoubtedly do much to attract attention to the value, to engineers interested in the subjects mentioned, of the volumes that may be consulted in this great library.

A book of decided value to railroad master mechanics and mill architects generally is "Railway Shops Up-To-Date," compiled by the editorial staff of the "Railway Master Mechanic." The purpose of the volume, which is a profusely illustrated quarto, is to supply all information necessary to show the conditions which controlled the design of the most important railroad shops recently constructed, and to illustrate the arrangement and equipment of the buildings for various purposes. The book takes up in turn the general lay-out of the shops, the locomotive shop, the blacksmith shop, the freight car shop, the passenger coach and paint shop, the planing mill, the foundry, the power house, the store house and the roundhouse. There is also an excellent bibliography of American articles on such structures. The purpose of the compilers has been to state what has been done and why it was done rather than to lay down generalities concerning theoretical conditions. (Chicago, Crandall Publishing Co., Security Bldg., $4.00.)

Messrs. Sherman M. Woodward and John Preston have rendered a service to engineers by translating the authoritative "Carbureting and Combustion in Alcohol Engines" of M. Ernest Sorel, whose researches for the Minister of Agriculture of France have attracted much attention in Europe. There is very little in the volume regarding the design of alcohol engines as they differ from others of the internal combustion class only in the carbureter. On the other hand it discusses in detail the principles upon which the satisfactory use of alcohol in such engines depends and gives the results of experiments and investigations which, if properly understood, will prevent costly attempts to accomplish the impossible. A good many people in the United States are now trying to make alcohol do more than its chemical and physical properties will accomplish, as this book clearly shows. The first chapter is a brief outline of the development of the internal combustion motor and of the use of alcohol in it. In the second chapter the conditions affecting the combustion of gaseous mixtures are reviewed and in the next chapter the phenomena of combustion of gaseous mixtures are described. Chapter 4 discusses the actual combustion in engines and the manner in which it is affected by variations in the air supply, the temperature of the cylinder walls and the time of ignition. The fifth chapter is devoted to the classes of carbureters and the conditions they must fulfill. The next chapter is on the temperature of vaporization. Investigations on carbureters are reported in chapter 7 and the following short chapter takes up the effect of temperatures below the temperature of combustion. In chapter 9 the instantaneous action of relatively moderate temperatures upon alcohol vapors and their derivatives is explained, while the slow action of relatively low temperatures is the subject of the next chapter. The eleventh chapter is an account of the effects of the simultaneous action of heat and oxygen on gases, and the twelfth chapter is a statement of the action of metals in the presence of various vapors free from oxygen. The book closes with a summary of the results of chemical studies on industrial alcohol. Mr. Woodward has contributed a useful introduction to the book in which Professor Lucke's tests of eight engines with alcohol are reviewed at some length. (New York, John Wiley & Sons, $3.00.)

Letters to the Editor.

Railways in the Philippines.

Sir: Possibly you will allow a modification of the statement concerning the railway work in the Philippines on p. 114 of your issue of Feb. 1, which reads as follows: "The property was accordingly taken over by an American corporation, the Manila Railroad Co., of which the New York banking house of Speyer & Co. is the head." Authority for the above is found on p. 26 of the Report of the Bureau of Insular Affairs for 1906: "This concession was transferred by Speyer & Co. to the Manila R. R. Co., a corporation organized under the laws of the State of New Jersey." This is apparently American. But in the "Statist" (London) of May 25, 1907, is a report of an extraordinary general meeting held on May 23, for the purpose of liquidating the affairs of the Manila Railway Co., Limited, at which the chairman said: "The old Manila Railway Co. will now disappear; the work will be carried on by an American company, who will be answerable to the English company, and in that way we shall hold our control over the whole undertaking." The undertaking is not quite so American as the President's American cable line in the Pacific.

This view is reinforced by an article in the "Journal" of the Asiatic Association, setting forth that with an expenditure of $437,494 the Visayan roads bought 81.2 per cent. of their supplies from the United States and 3.6 per cent. from the United Kingdom and Hong Kong. The Manila concern, with a like expenditure of $442,265, bought 50.2 per cent. from the United Kingdom and Hong Kong, with 30.6 per cent. from the United States. This relation is referred to by the "Journal" as follows: "Purchases for the Visayan system are largely from the United States, but the Luzon system, preserving the British tradition of the original Manila-Dagupan line, of which it is an expansion, is credited with heavy purchases from the United Kingdom."

The nationality of the engineers employed on the two systems is not referred to.

New York, Feb. 5. Edward P. North.

Reducing the Effect of Backwater on Water-Wheels.

Sir: In your Current News Supplement of Jan. 4, I notice a "Fall Increaser" which has been recently patented by Mr. Clemens Herschel, of New York. In looking this over it occurred to me that I had seen something of a similar character in a magazine or paper some years back, and in thinking over the matter I located where I had seen it. I enclose a diagram of the apparatus, which, to all intents and purposes, is the same and serves the same purpose as Mr. Herschel's device. I also enclose the first part of the article in this same magazine. This diagram and description were published in a paper, or series of papers, written in 1831. These papers were bound under the name of "Elements of Technology—Taken Chiefly from a Course of Lectures Delivered at Cambridge, Mass., on the Application of the Sciences to the Useful Arts," by Jacob Bigelow, M.D.; publishers, Hilliard, Gray, Little & Wilkins; dated 1831.

Hoping this may be of interest to your readers, I am taking the liberty of sending this to you.

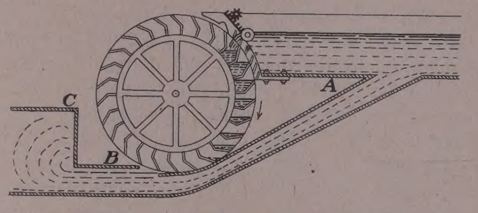
Yours very truly,

Boston, Feb. 4. Henry D. Jackson.

[The description sent by Mr. Jackson reads as follows:

"The back water, or tail water, is that portion which has passed by the wheel.

"This portion is not only useless, but in most cases injurious, since by its inertia and weight it resists the escape of the floats and empty buckets in their passage upwards.



Reduction of Backwater Effects.

"Its effect is increased in time of floods or freshets, so that it is often necessary to place wheels higher than they otherwise would be to provide against it. A method of getting rid of back water in times of flood, has been invented by Mr. Perkins in this country, and Mr. Burns in Scotland. It consists in a separate passage by which a current of water is taken from the mill-lead, or flume, as at *A* in the figure, and passes with great rapidity under the wheel, and thence under the flooring at *B*. This rapid current has the effect to take off and carry away the back water from beneath the wheel, while it is prevented from returning by the force of the same current and the barrier at *C*. The water which is expended to maintain this current is no more than would run over the waste gate in a time of freshet."]

Failure of Large Steel Beams.

Sir: With respect to the article in The Engineering Record of Dec. 28, 1907, on "Failure of Steel Beams," I beg to state that a somewhat similar failure of rolled steel by dropping recently came to my attention, and the following information may be of some interest:

A large girder for a deck structure was being raised in place on abutments and had been lifted to the height of the abutment, about 15 ft., when the derrick boom broke, dropping the girder the full height of the abutment, and, as it was being raised flat, it struck on the top corner of one end. The resulting injury to the girder was a crack through the top leg of the outstanding top flange angle and severe bends in both the top and bottom flanges. The top flange was taken apart and the following tests made on material of the broken angle:

Tension Tests.—Elastic limit, 35,790 lb.; tensile strength, 63,700 lb.; elongation, 29.25 per cent. in 8 in.; reduction of area, 55.14 per cent.; fracture, silky; bending and drifting tests satisfactory.

Chemical Tests.—Sheared end: Carbon, 0.32; phosphorus, 0.042; manganese, 0.59; sulphur, 0.042. Fracture end: Carbon, 0.27; phosphorus, 0.035; manganese, 0.53; sulphur, 0.034.

These results comply with the requirements for medium grade of bridge material, with the exception that there is some variation in the carbon and manganese, which is higher than the usual run of material. The investigation, therefore, leaves only the variation of high carbon and manganese to probably account for the break in the angle.

Referring to the results of chemical analysis given by Mr. Greene in the issue of Dec. 28, they evidently represent Bessemer steel, whose composition was incorrect for structural material. The phosphorus and manganese are entirely too high and undoubtedly the failure was due to the brittleness of the beam from this cause. In fact, all of the elements are higher than is found in the general run of commercial steel and higher than permitted by standard specifications.

Referring to Mr. Greene's suggestion that each and every beam should be carefully tested, I would say that, of course, under present-day commercial conditions, this would be practically impossible on account of the time and expense, and dependence must be placed on careful testing at the rolling mills of each heat of steel used, together with surface inspection at the mill or at the shop. Burning during the process of reheating may cause brittleness and careful surface inspection can generally discover this defect.

I do not see any reason for the belief that the quality of large I-beams is not up to that of the smaller sections. They undoubtedly require greater care and more work at the furnace and in rolling, which is entirely up to the manufacturers. I believe, however, it is a fact that the large sections, from 15 to 24 in., show up as well under the usual mill tests and in service. Stock material is often the source of trouble; the quality of the general run of material which has been rolled for some time and in storage cannot be positively identified, even by record mill tests, because as cut in commercial lengths, the heat numbers are not on the material and for a positive identification of the quality of all pieces, test specimens 18 to 20 in. in length must be cut from each piece, as every piece may be from different heats and each heat will vary. To perform this testing too much time and expense is involved, and besides the cutting of the test specimens would spoil the commercial length of the pieces. Therefore, when such material taken from stock is used, its absolute quality must be assumed. Purchasers of material from stock should take this into consideration. Where identification between heat numbers and mill records can be secured, the quality can be determined, otherwise only a reasonable assurance can be placed on securing a generally satisfactory commercial grade of steel. By observing the action of the material under punching and by bending and drifting tests made on cuttings and crop ends, the use of brittle stock material can often be prevented.

Very truly yours,

Watson Vredenburgh, Jr.

New York, Feb. 6.

Iron and Steel Pipe may be readily distinguished by a flattening test, according to statements made at the recent meeting of the American Society of Heating and Ventilating Engineers. Soft steel pipe, cut in very short lengths or rings, flattens smoothly and evenly without breaking, while wrought iron pipe usually fractures at two or more places when flattened.